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BIRD STUDY IN THE MISSISSIPPI VALLEY.[1]

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For this discussion I wish to divide the subject into two headings, the first being a statistical study of the membership of the three principal bird societies of the United States, and the second, a discussion of the number of bird courses given in the colleges and universities of this region—the Mississippi Valley. At first thought these subjects may appear either not at all or only remotely related to each other, but I hope to make the interrelationship clear as I proceed.

BIRD SOCIETY MEMBERSHIP.

The following table of membership in the three principal ornithological societies is compiled from the latest published lists of members, all of which appeared last spring (1919), and includes all classes of members in each case.[2]

Membership in Ornithological Societies.

	A. O. U.	Cooper	Wilson	Total
Eastern States:				
Maine (2)	17	1	0	18
New Hampshire	11	0	1	12
Vermont (1)	8	1	0	9
Massachusetts (23)	204	40	13	257
Rhode Island	11	3	4	18
Connecticut (5)	34	13	10	57
New York (19)	123	33	23	179
Pennsylvania (7)	75	14	13	102
New Jersey (3)	37	9	7	53
Delaware	0	0	1	1
Maryland	10	2	1	13
West Virginia	3	0	1	4
Washington, D. C. (27)	63	29	11	103
Southern States				
Virginia	4	1	2	7

[1]Revised from paper read before The Wilson Ornithological Club, at St. Louis, Mo., Dec. 29, 1919.

[2]American Ornithologists' Union list from *The Auk*, Vol. 36, pp. XIII-XLV, April, 1919; Cooper Ornithological Club list from *The Condor*, Vol. 21, pp. 135-144, May, 1919; Wilson Ornithological Club list from *The Wilson Bulletin*, Vol. 31, pp. 29-40, March, 1919.

North Carolina	3	1	1	5
South Carolina (1)	7	1	1	9
Georgia	1	1	1	3
Florida (1)	3	3	2	8
Alabama	2	0	0	2
Mississippi	0	0	0	0
Louis ana	3	3	3	9
Texas (1)	5	6	3	14
Central States:				
Michigan (2)	16	6	18	40
Ohio (1)	21	8	41	70
Indiana (1)	9	3	13	25
Kentucky	1	0	0	1
Tennessee (1)	4	0	8	12
Wisconsin	11	0	7	18
Illinois (4)	48	21	66	135
Minnesota (1)	13	5	6	24
Iowa (1)	7	3	51	61
Missouri (2)	7	5	4	16
Arkansas	0	2	1	3
North Dakota	1	0	3	4
South Dakota	2	0	3	5
Nebraska (1)	5	6	48	59
Kansas	5	7	7	19
Oklahoma	1	1	0	2
Western States:				
Montana	2	2	0	4
Idaho	3	2	0	5
Wyoming	1	0	0	1
Colorado (2)	21	12	6	39
Utah	5	11	0	16
Nevada	1	4	0	5
Arizona	1	8	0	9
New Mexico	4	3	0	7
Washington (2)	11	18	3	32
Oregon (2)	9	13	0	22
California (16)	50	278	13	340
Alaska	2	1	1	4
Canada (4)	27	19	14	60

In the Wilson list, under Nebraska, are included forty-seven names of members of The Nebraska Ornithologists' Union, a society affiliated with the Wilson Ornithological Club. There is some duplication of names, as often a single person belongs to all three societies, but it is probably true that such an individual is worth three times as much to ornithology as the person who belongs to only one society. The present membership is undoubtedly somewhat larger than these figures show, as the study of ornithology has been taken up with renewed vigor since the close of the war, and a more or less energetic campaign has been carried on for members in the several societies. To illustrate the increase, I have a letter from Dr. T. S. Palmer, Secretary of the American Ornithologists' Union, in which he states that since the election last November, there are now twelve members in Kansas, whereas the table shows only five. However, even if these figures are somewhat out of date, the main

facts I wish to bring to your attention will still be illustrated by them, and as they are of equal age for the three societies, comparisons are possible.

It will be noticed at once that the Southern States are especially short of members. This may be due to several reasons, probably the largest one of which is general apathy on the part of the educated classes towards bird problems of the day. Certainly we have had few indications from the lawmaking bodies of the states in question to manifest that they are interested in bird protection, and they must reflect to a large degree the general condition. However, some valuable bird reports have come from Southern States, as those of North and South Carolina. Perhaps lack of members is due to the fact that no serious campaign for them has been carried on. If such is the case it can easily be remedied. The colleges and high schools make natural focal points for starting such a campaign, but those of the South are not as well organized, especially in the sciences, as they are in the North.

Both the East and West have heavy memberships, centered in the former region in Massachusetts and New York, and in the latter, in California. And both of these centers are carrying on active work of a high class.

Turning to our own territory, the Mississippi Valley, we find some States with a good number enrolled, as for example, Ohio Illinois, Iowa and Nebraska, but most of the remainder are a long way behind where they should be. And one of the strange facts is that we have one of the best territories for bird study on the continent, owing to the fact that we are on the migration route of so many species. Certainly right at home is our field for doing missionary work to convert more people into bird lovers and bird students, and to get them to express their interest by joining a bird society.

The American Ornithologists' Union has three classes of members, the lowest class being Associates, number unlimited, the second class being Members, limited to one hundred, and the highest class being called Fellows, of which there can be no more than fifty. Associates are elected to the higher classes for exceptional research in some branch of ornithology, so it is safe to presume the one hundred fifty names contained in the lists of Fellows and Members of the A. O. U. contain the most imminent bird men in the country. In the above table, the numbers in parentheses directly following the name of the state repre-

sents the total of Fellows and Members of the A. O. U. who reside therein, according to the published list. If we study this list of one hundred fifty names, we find their totals tally rather closely with the totals in the last column, representing the total memberships in all three societies, with the exception of the District of Columbia, this being due, of course, to the large number of scientists in Washington employed by the Government. They also seem to center around large museums, and this leads to the conclusion that the majority of them gained their standing through systematic work. Such has probably been the case in the past, but during recent years other lines of endeavor are beginning to take the place of systematic study.

It is probable that the close association of imminent ornithologists with the totals of membership in the three societies is due to the fact that when a man is especially interested in a subject he emanates enthusiasm to those around him, and they are much more liable to become interested in the same line of work. The interest of these men would also lead to a more virile campaign for members, and so an endless chain would be started.

The Central States have a total of fourteen names in the list of Fellows and Members of the A. O. U., Illinois leading with four. This is fair, but below what we should have. However, it is in proportion to our total memberships. I think the workers of this region often let outside ornithologists come in and do our good things for us. I know this is true of the North Dakota lake region, and other places. Or perhaps our best men leave us for fresh bird fields.

Courses in Ornithology.

Regarding the number of colleges and universities in the Mississippi Valley which give courses in ornithology, I find there are a total of about one hundred forty schools of this rank having over one hundred college students, and of these, thirty-four give such a course, one other (probably more) offers considerable bird study as part of another course in zoology, and one hundred five give no such work, so far as I am able to learn. In other words, approximately thirty per cent of the institutions give bird courses.

The following table gives in tabular form a few particulars regarding the courses given in the institutions offering ornithology. It is compiled almost entirely from information gained from a questionnaire sent to the teachers giving these courses,

or to the heads of the biology or zoology departments, when such instructors were unknown. The responses were prompt and full, and I wish to thank those who so kindly cooperated with me in this effort.

Institution	Courses given	Hours of credit	Semester fee	Laboratory
Baldwin-Wallace, O.	1	2	$1.00	Yes
Carthage, Ill.	1	2	3.00	Yes
Central, Mo.	1	2-3	None	Yes
Coe, Ia.	2	6	5.00	Yes
Doane, Nebr.	1	1	None	None
Drake, Ia.	1	5	1.00	Yes
Drury, Mo.	1	2-3	2.00	For extra hour
Earlham, Ind.	1	2	1.00	None
Eureka, Ill.	1	3	None	Yes
Fargo, N. Dak.	1	3	2.00	Yes
Hastings, Nebr.	1	3	2.00	Yes
Hillsdale, Mich.	1	2	1.00	Yes
Illinois	2	4-7	None	Not in elementary
Illinois Wesleyan	2	4	2.50	Yes
Illinois Woman's Col.	1	1	.50	None
Indiana	1	2	1.50	Yes
Iowa	2	6	None	Yes
Iowa Wesleyan	1	2	1.00	Yes
Kansas	1	3	1.50	Yes
Kentucky	1	3	None	Yes
Knox, Ill.	1	1	1.00	Yes
McPherson, Kans.	2	8	2.50	Yes
Mich. Agricultural Col.	1	5	1.00	Yes
Minnesota	2	4	None	Yes
Morningside, Ia.	1	4	2.00	Yes
Nebraska	1	1	2.00	Yes
Oberlin, Ohio	3	5-6	2.00	Yes
Ohio State	1	2	None	Yes
Ohio Wesleyan	1	2	1.00	Yes
Washburn, Kans.	1	2	1.00	None
Western Reserve, O.	1	3	5.00	Yes
Wilmington, Ohio[2]	1	2	None	
Wisconsin	1	2	1.50	Yes
Yankton, S. Dak.	1	3	Yes	Yes

There is considerable variation in the nature of the single elementary course given by most of the schools, some of them making it a popular study with no prerequisites, while in others it is an advanced course with a year of biology or zoology before it. Of one course of the former character, the instructor says: "Perhaps we should call it a bird club rather than a class." From this on the one hand, we pass to the more pretentious classes, and finally to those where a second course in ornithology is given. In most of the schools, the second course, is like the first, general in nature, but more advanced. In Illinois, the elementary course does not have laboratory, but the advanced does. In Minnesota, the first one has laboratory but no field

[2]From 1919 catalogue.

work, while the second is the reverse. In Oberlin the first two courses are general, but "The other spring course is entirely devoted to the study of current migration."

The number of semester hour credits given varies from one to five for a single course, and from four to eight for two or three courses. In the case of McPherson College, where eight may be obtained, "This course is by appointment and credit depends on amount and grade of work done."

Fees vary from none to $5 per course. The average for those given, not counting the ones where no fee is charged, is $1.83. The fee in connection with three or four hour courses should probably be somewhat higher than this, judging from the two following quotations, where the fee is $2: "Should be more to cover expense of skins and mounts injured and destroyed by students." "Fee should be higher, but students usually have to buy a field glass and one or two books, and we have hesitated about raising the fee." Where there is no fee at present, we hear that "We will add a fee next year," and "None this year. Think we should have a fee of at least $2." It looks as if the H. C. L. has hit bird courses as well as everything else!

Five of the colleges do not offer laboratory work with their bird courses. In the rest it varies considerably, according to material available and inclination of the instructor. Without exception, field trips are included in every course given. There is a great deal of variation as to how much of the time is put in in this way, but in most of the courses field work forms a substantial and important part. The early weeks of the course seem more likely to be devoted to laboratory and the latter ones to field work. The migration period and weather conditions have an important bearing on the time and proportion of each. Very often we find the statement that the class has either laboratory or field trips every week, the one taking the place of the other.

If the schools giving bird courses listed in the above table are arranged by States, it will be seen that Illinois and Ohio lead with six, while Iowa is a close third with five. If one refers back to the table of membership in the bird societies, it will be noted these same three States lead the Central group in total members, and in the order named. In fact, this relationship between the number of institutions giving courses in ornithology and the total membership in bird societies continues all down the line with remarkable regularity, as shown in the following table:

State	Colleges	Members	State	Colleges	Members
Illinois	6	135	Minnesota	1	24
Ohio	6	70	Wisconsin	1	18
Iowa	5	61	South Dakota	1	5
Nebraska	3	59	North Dakota	1	4
Kansas	3	19	Kentucky	1	1
Michigan	2	40	Tennessee	0	12
Indiana	2	25	Arkansas	0	3
Missouri	2	16	Oklahoma	0	2

If the sizes of the institutions concerned and the length of time the courses have been given are considered, I am sure the few irregularities in the above table could be accounted for. This parallelism leads one to the conclusion that there is a close relationship between courses in ornithology in our colleges and universities and the prosperity of our bird societies. Most students become interested in and enthusiastic about birds when studying them, and if their attention is called at the proper time to the work of the societies, a considerable proportion will join and keep up their membership. But we must have teachers who believe in bird societies themselves.

In this connection, it is interesting to note that the teachers of these thirty-four bird courses are as a rule not members of a bird society. In the lists of members of the three societies above referred to, we find the names of the instructors giving these courses appearing a total of twenty-four times, distributed as follows: A. O. U., ten; Cooper, five; Wilson, nine. But two persons belong to two societies, and five, to all three. This reduces the number of individuals belonging to twelve, or a little over one-third of the total number. The reason for this lack of interest probably comes under one of the following heads: First, it may be for financial reasons. If this is the case, it would be a good idea to join, and let the school pay the fee from its library fund and place the magazines as received in the library. If the course is worth giving, it is worth providing magazines for. Second, this lack of interest may be due to lack of knowledge of the existence of these societies. In my own case, I discovered it more or less by accident. There are very few mentions in bird literature of these societies and the work they are doing. Persons interested in their growth do not seem to realize the value of publicity. It cannot be done to any great extent through the magazines the societies themselves publish. A third reason is that a good many of the instructors are not interested in the investigation side of ornithology, and as a result they find little to interest them in the literature or magazines

published by the societies, as these seem too often to run to technical matter of interest to no one except the specialist. The Cooper Club seems to be meeting this situation to a certain extent, and a considerable portion of *The Condor* is really readable, with numerous pictures. The one other drawing card the societies have is their annual meetings. But it is only once in a while that a person is near enough to the place of meeting to be able to attend one of these, so, for most members, they are few and far between, and this advantage of membership is largely negative. The Wilson Club has wisely become affiliated with the American Association for the Advancement of Science, and as a result their annual meetings are held at the same time and place as the meetings of a large group of other scientific societies. This should add greatly to the attendance and interest in these gatherings, and make them well worth while. The Cooper Club has tried to solve this question by having monthly meetings in centers where there are enough members to warrant them. This combines features of both local and national bird societies, and seems to be working well.

The Mississippi Valley is the special territory of the Wilson Ornithological Club, and this society deserves our special support for this reason, if for no other. There are four classes of members, Honorary, Sustaining, Active, and Associate, and the membership (March, 1919) is 4, 18, 203 and 194 for the four classes respectively. The club publishes *The Wilson Bulletin*, a quarterly of from forty to fifty pages a number. This is now in its thirty-second volume, and is under the able editorship of Dr. Lynds Jones, of Oberlin. As mentioned above, the annual meetings are in conjunction with the meetings of the A. A. A. S., and for this reason should be comparatively easy to attend, especially for science teachers.

In conclusion, we need more members in our bird societies, and there are two places from which to draw them, either from the ranks of those who are already interested in the subject, or by making more bird lovers from which to draw. To reach persons at present interested in the subject is a problem that is up to the officers and members of the societies. That the surface has hardly been scratched is shown by the large per cent of teachers giving bird courses who are not members of any organization of national scope. This being so, a moments thought will lead one to conclude there must be even a larger per cent of laymen outside the membership rolls. In regard to making more

bird lovers, from the figures given above, certainly there is no better way than by giving courses on birds in our colleges and universities. A little knowledge in this case does not usually prove to be a dangerous thing, but, on the contrary, serves as leaven for a more intimate knowledge and growing interest as the years go by. And if such students can be interested in a bird society, it will help keep them in touch with the subject for the rest of their lives, and here and there among their number may be found a real bird student, the kind we must have to keep ornithology on a level with the other sciences.

PRODUCTION OF CADMIUM IN 1919.

The output of metallic cadmium in 1919 was 99,939 pounds, compared to 127,164 pounds in 1918 and 207,408 pounds in 1917, the maximum output in the history of the industry. The production of cadmium sulphide was 31,197 pounds, compared to 51,702 pounds in 1918. The combined value of metallic cadmium and cadmium sulphide in 1919 was about $160,000, compared to $258,518 in 1918 and $376,036 in 1917. These figures, computed by C. E. Siebenthal, are made public by the U. S. Geological Survey, Department of the Interior.

Though prices of cadmium were somewhat lower in 1919 than in the three years immediately preceding, the industry closed the year in better condition than in 1918, for the reason that the consumption practically reached the level established in 1916-17, and this with the decreased production operated to reduce stocks.

LIGHT FOR RETOUCHING.

An expert in retouching writes very sensibly in *The British Journal* as follows: "In the days when I did a good deal of retouching I found it best to avoid any arrangement which allowed any light, however diffused, to fall directly on the negative, as it was always very trying to the eyes, and I maintain that retouching ought not to produce eye-strain if the negative is properly illuminated. I have often retouched till long past midnight without getting my eyes tired. The arrangement I have always used, whether the source of light was paraffin-lamp, incandescent gas, electric or daylight, allowed no light to fall directly on the negative, but was all sent upward through the negative by reflection from a sheet of white paper, or if the negative was extremely dense a piece of matte sheet-aluminium was used instead.

"Eye-strain in retouching is caused by trying to see every stroke made by the pencil. I believe that it may be almost entirely avoided by working at such a distance that each touch is not seen but only the general effect, working just as an artist does when he 'stipples' in watercolor or minature-painting.

"Many retouching-desks are not sufficiently upright; the slope of the desk should not be less than sixty degrees. This will be found more restful and healthy, and will not cause the worker to stoop. This was the angle of the desks used by the mediaeval writers, who spent their lives writing at a time when writing was a fine art. I often wonder that men who spend their days 'pen-pushing' do not use a desk with a steep slope, they would get far less indigestion and have straighter backs."—*Photo Era.*

RESEARCH IN CHEMISTRY.

Conducted by B. S. Hopkins.
University of Illinois, Urbana.

It will be the object of this department to present each month the very latest results of investigations in the pedagogy of chemistry, to bring to the teacher those new and progressive ideas which will enable him to keep abreast of the times. Suggestions and contributions should be sent to Dr. B. S. Hopkins, University of Illinois, Urbana, Ill.

THE POSITIVE ELECTRON AND THE BUILDING OF ATOMS.[1]

BY WILLIAM D. HARKINS,
The University of Chicago.

The discovery of the negative electron may be said to be due to Sir William Crookes and to J. J. Thomson, though this form of electron was first definitely recognized by the latter. The mass of this electron is very small, and is only about 1-1835 of that of the hydrogen atom, the lightest of all atoms. The mass of any atom, as is well known, is almost altogether associated with its positively charged part, and not with the negative charge. While the idea that the positive part, or nucleus of the hydrogen atom, "*may* be the positive electron" is quite a common one, there was evidence that seemed conclusive, which was considered to show that this was probably not the case, the evidence being that the atomic weights of chlorine, magnesium, and silicon, and many other elements, are not at all nearly multiples of the atomic weight of hydrogen by a whole number.

In 1915 I developed a theory of atom building which gave a rational explanation of this apparent discrepancy, and showed with considerable conclusiveness that all of the other atoms are built up from hydrogen nuclei, which therefore are the positive electrons, and of negative electrons, the mass of the atom being due almost entirely to the former. Four positive unite with two negative electrons to form the nucleus of the next heavier atom, that of helium. This is the well known alpha (α++) particle which is shot off at high speed from radioactive atoms when they disintegrate. These alpha particles are the most important constituents, from the standpoint of mass at least, in all of the heavier atoms. This theory soon led to the discovery of a new periodic system which is of great importance

[1]Abstract of a general address presented at the Philadelphia meeting of the American Chemical Society, September 3, 1919.

in connection with the evolution of the atoms, or what is commonly, but less correctly known as the evolution of the elements.

THE NEW PERIODIC SYSTEM OF THE ATOMS.

What is usually known as the periodic system of the elements was developed largely in the decade from 1860 to 1870, during the period of our Civil War, by de Chancourtois, Newlands, Mendeléeff and Meyer. Mendeléeff, the third to develop the system, has been given almost all of the credit for it, but this is largely because he paid very much more attention to its details than any of the three others. It has now been found that the Mendeléeff periodic relation is simply one method of expressing the arrangement in space of the electrons in the outer part of the various kinds of atoms.

Five years ago I discovered a *new periodic system of the elements, or more properly speaking, of the atoms. This second system is not at all directly related to the arrangement of the electrons in the outer part of the atom, but has been found to indicate how the atoms are built up, that is, it is related to the structure of the nuclei of the different species of atoms.*

In order to understand the meaning of this new periodic system it is important to have a good idea of the present theory as to the general structure of the atom. According to Rutherford the atom is similar to the solar system in that it has a central sun called the nucleus of the atom, and a system of planets, each of which consists of one negative electron. The atom as a whole is electrically neutral, and the electrons outside the nucleus, which we may call the planetary electrons, are held in the atom by a positive charge on the nucleus. This positive charge is equal numerically to the sum of the charges of all of the planetary electrons. This is often expressed by the statement that the number of positive charges on the nucleus is equal to the number of negative electrons, since it is known that the hydrogen ion carries a positive charge equal to the negative charge on the negative electron.

The atom is similar to the solar system in a second sense, for the planetary electrons are, relative to their size, about as far from each other and from the nucleus, as the planets and the sun. Thus it need not be surprising from this point of view, that Rutherford has found that the very minute nucleus of a helium atom, often called the alpha particle, may be shot directly through many thousands of other atoms, without hitting a single nucleus

or a single negative electron, just as a planet like the earth might be shot through thousands of solar systems like our own without hitting a single sun or planet.

The atom is like the solar system too, in that the nucleus, like the sun, possesses nearly the entire mass of the system, since in general the nucleus is about two thousand times heavier than all of the electrons which surround it. While the atom is so small that a row of fifty million atoms would be only about one inch long, if they were put as closely together as they are in solids; and so small too, that there are 180 thousand billion billion atoms of carbon in one cubic centimeter of diamond; the atom is so *large* compared with the electron, that, if we take the dimensions usually accepted for the electron, there would be space in a single atom sufficient to contain ten million billion electrons, while the atom which contains the greatest number of planetary electrons, uranium, actually has only ninety-two of these. According to the work of Rutherford, Geiger, Darwin and Marsden, the nucleus of even the heaviest atom, is not very much larger than a negative electron. Thus the atom may be said to be very sparsely populated with electrons, or an electron in an atom occupies somewhat the same relative space as a fly in a cathedral.

The atom is *unlike* the solar system in that the planetary electrons are arranged more or less symmetrically in space around the nucleus, at least that is the idea expressed in papers by the American chemists, Parsons, Harkins, Lewis, and Langmuir.

Also, while the solar system is held together by the gravitational attraction between the large mass in the sun and the smaller masses in the planets, the atoms are held together by the positive electrical charges in the nucleus and the negative charges of the electrons, together with whatever magnetic effects are produced by the rotation of the electrons.

The Building of Atoms.

While chemists have not as yet synthesized any atoms, it is also true that they have only recently begun the study of their structure. Now, when a chemist wishes to build up even such a simple thing as an organic molecule, he first studies its structure, and often many years intervene between the working out of the structure of the molecule and its first synthesis. In the synthesis of an organic dye there may be two steps which we may have to consider. Suppose for example that the first of

these consists of a complex set of reactions which are very difficult to carry out, while the second step will occur by itself if the intermediate product is only left standing in the air. It is evident that the practical chemist will need to put almost his whole attention on the first step of the synthesis. The building of atoms is similar in that the first step, the building of the nucleus of an atom, has not yet been accomplished, while, if the nucleus were once built, it would of itself pick up the whole system of planetary electrons which would turn it into a complete atom. For example, in the disintegration of the nuclei of certain radioactive atoms, alpha particles, which are the nuclei of helium atoms, are shot out as rapidly as twenty thousand miles per second, so rapidly that they pass through as many as *half a million* other atoms before coming to comparative rest. Now Rutherford has proved that when these nuclei finally slow down, they give the ordinary spectrum of helium, which indicates that each alpha particle has picked up the two negative electrons which are essential to convert it into a complete helium atom.

The Building of the Nuclei of Complex Atoms.

Suppose that we consider the specific problem of the building of a carbon atom. The characteristic chemical and physical behavior of carbon is due to its six planetary negative electrons, and these will arrange themselves around any nucleus which carries a positive charge of six, so our problem reduces to that of putting six positive charges of electricity into the extremely minute space occupied by the nucleus of an atom, with a diameter of the order of 10^{-12} cm., that is one millionth of a millionth of a centimeter. These six positive charges must not only be put into this *ultra-ultra-microscopic* space, but must unite to form an intra-nuclear compound of extreme stability.

Now, up to the present time, the smallest mass ever found associated with one positive electrical charge is that of the hydrogen ion, which is associated primarily with the mass of the hydrogen nucleus, with a value of 1.0078.[2] If six of these hydrogen nuclei could be packed tightly enough together to form the nucleus of a new atom they would form the nucleus of a carbon atom, which would have a mass of approximately six. That no carbon atom of this mass exists is not because such a nucleus, if formed, would not give a true carbon atom, but because six positive hydrogen nuclei undoubtedly repel each other, and can not be made to form a stable system.

[2]Equal to 1.66×10^{-24} grams.

In order to make a complex nucleus stable it is necessary to include not only hydrogen nuclei, but also negative electrons. Since the mass of the ordinary carbon atom is 12.00, it could be built up from 12 hydrogen nuclei, bound together by six negative electrons. Such a nucleus would have a positive charge of 6, it would therefore take up six negative electrons, and would thus form a complete carbon atom. The only objection to this idea is that 12 times 1.0078 is 12.036, while the weight, and probably the mass, of the carbon atom is only 12.005, or the actual carbon atom is 0.76 per cent lighter than it would be if built from 12 hydrogen nuclei without any resulting change of mass. Now Professor A. C. Lunn has worked out the mathematical expression for this effect for the writer, and this shows that according to the electromagnetic theory, if such a nucleus is held together in a very small space by attractive forces there *should* be a loss of mass in its formation, and that in a simple atom the observed loss of mass would result if the center of the negative electron has a distance 400 times the radius of the positive electron.

The alpha particle, or the nucleus of a helium atom, carries two positive charges, has a mass of four, and is probably made up of four positive hydrogen nuclei bound together by two negative electrons into what is probably by far the most stable nucleus of any known atom, except that of hydrogen itself.

If we consider the atomic number[3] of the element to be equal to the positive charge on the nucleus, then the atomic number of hydrogen would be one, that of helium two, that of carbon six, of lead eighty-two, and of uranium, ninety-two. Now the mass of the carbon atom (atomic number 6) is exactly what it should be if its nucleus consists of 3 alpha particles. Also, 3 times the charge on the alpha particle is just the charge on the carbon nucleus. It is easily seen that there is a possibility that the carbon nucleus is simply a compound made up of 3 alpha particles, of a formula 3α. Now it is obvious that if the nuclei of complex atoms were simply structures built up from alpha particles, that, since the positive charge on the alpha particle is two, there would be no nuclei with an odd number of charges.

[3]The atomic number of an *element* is its number in the periodic system of Mendeleeff, and is equal to the number of net positive charges on the nucleus of an atom, that is the number of positive minus the number of negative electrons in the nucleus, and is also equal to the number of the planetary electrons. An element may consist of several kinds of atoms (isotopes) with different atomic weights, but all of the atoms of one element have the same number of positive charges on the nucleus, and the same number and the same arrangement of planetary electrons. Thus one element may consist of several species of atoms, all of which act alike chemically, but differ in mass and the structure of the nuclei.

The work of Moseley indicates, however, that the elements of odd atomic number also exist, but it is certain that the nuclei of such odd numbered atoms can not be compounds made of alpha particles alone.

On the other hand, it is quite evident, as I announced four years ago, that the nuclei of the atoms of even atomic number are mostly intra-nuclear compounds of helium nuclei. For this there is much evidence which will be found in my papers in the *Journal* of the American Chemical Society and in *Science*.

I wish to show just a little as to the way in which these alpha particles are bound together.

First, the atomic weights of the lighter atoms of *even* atomic number beginning with carbon are, 12, 16, 20, 24, 28, 32, 40, 40, 48, 52 and 56, the last being the atomic weight of iron, of atomic number 26[4]. Thus the atomic weights of the atoms whose nuclear charge is expressed by an even number are divisible by 4, the weight of the helium nucleus. If we study the elements of high atomic number, beginning with uranium, which is number 92, we find that the even numbered atoms change into the atom of next lower even number by the loss of a single alpha particle from the nucleus of the atom. Thus we find just the same system of structure indicated by the actual disintegration of the radioactive atoms as is made evident by the atomic weights and the nuclear charges on the atoms of low atomic weight.

Second, the atomic weights of the elements of odd atomic number point to the idea that their nuclei are compounds of a certain number of alpha particles with three hydrogen nuclei, so that their formula is $n\alpha+3h$. In the exceptional cases of nitrogen the formula is $3\alpha+2h+\epsilon$.

Four years ago I presented the following formula for the respective nuclei:

$$\begin{aligned} \text{Carbon nucleus} &= 3\alpha \\ \text{Nitrogen nucleus} &= 3\alpha+2h+\epsilon \\ \text{Oxygen nucleus} &= 4\alpha \end{aligned}$$

where ϵ represents a negative electron.

It is of extreme interest in this connection to note that Sir Ernest Rutherford has just announced that he has been able to bombard these atoms with extremely rapid moving alpha

[4]It is of extreme interest to note that the mass of the alpha particle is 4.00, and that its positive charge is 2 and that also the mass of the nucleus of the complex atoms is found to increase by 4.00 whenever the positive charge increases by 2.

Hd.

m > 4 17
e > 2

x² 1d

particles, and that he has been able to drive hydrogen out of nitrogen atoms, but not out of either carbon or oxygen.

The plan according to which the nuclei of the lighter atoms of even numbered nuclear charge are built up, is so simple that it might easily be made the subject of oral problems in arithmetic for the elementary schools. Thus knowing that these complex nuclei are made up from alpha particles alone, and that each alpha particle weighs 4.0 and has a positive electrical charge of 2, the problem might be given as follows: The nucleus of the sulphur atom carries a positive charge equal to 16 (for this the evidence is good); how many alpha particles does it contain? The obvious answer is 8. If the number of alpha particles is 8, what is the weight of the sulphur atom? Answer $8 \times 4 = 32$, which is the atomic weight of sulphur as given by experiment.

If this system holds exactly the following theoretical table should give the atomic weights and the charges on the nucleus, the latter being equal to the atomic number:

Atomic Number	Atomic Weight
2	4
4	8
6	12
8	16
10	20
12	24
14	28
16	32

Now, the extremely remarkable fact is that *the atomic weights given above are the atomic weights of the even numbered elements,* with only one exception.

If the twenty-six elements from helium to cobalt (atomic weights from 4 for helium to 59 for cobalt), inclusive, are considered, it might be assumed that the even numbered, or one half of the elements, should have atomic weights divisible by 4. Indeed, while there are two exceptions to the exact system, just 12 of these elements do have such atomic weights, and every possible multiple of 4 but two is taken, as is shown in the following table:

1×4	= helium	8×4	= sulphur
2×4	= missing, and replaced by $2 \times 4 + 1$	9×4	= missing, but replaced by 10×4 = argon
3×4	= carbon	10×4	= calcium
4×4	= oxygen		
5×4	= neon	12×4	= titanium
6×4	= magnesium	13×4	= chromium
		14×4	= iron

Thus, since the *even-numbered* elements of *high atomic weight* give off *helium atoms* when they disintregate, and in such a way

that for each helium atom lost the *heavy atom* changes into the atom of the element which has an *atomic number which is smaller by 2;* and since the *even-numbered elements of low atomic weight* have *atomic weights which increase by four, or the atomic weight of helium, for each increase of 2 in the atomic number, the natural assumption is that the even numbered elements are compounds of helium.* To distinguish them from chemical compounds they may be called intra-atomic. At least for the elements of low atomic number, their general formula is nHe', where the prime is added to indicate an intra-atomic compound. That is, the formula of the nucleus is $n\alpha^{++}$.

While the nucleus of the carbon atom consists of 3 alpha particles alone, and that of sulphur of 8 alpha particles, and while the other nuclei which consist of 4, 5, 6, and 7 alpha particles are also well known atoms, no nucleus contains more than ten alpha particles unless it contains some negative electrons other than those in the alpha particles themselves, which are used in binding on extra alpha particles. Thus the argon nucleus consists of ten alpha particles plus 2 negative electrons, while the nucleus of the calcium atom consists of 10 alpha particles without any negative electrons aside from those inside the alpha particles. Thus the argon and the calcium nucleus contain the same number of alpha particles, but not the same number of negative electrons. The only difference between an argon and a calcium atom is that the former has two electrons in its nucleus, which in the calcium atom are in the outer shell of the planetary electrons, that is they are valence electrons. Thus the argon and calcium atoms are *isomeric.*

The Negative Electrons in the Nucleus Are Associated in Pairs.

The negative electrons which are used in binding extra alpha particles on the nucleus always go in pairs, and may be called cementing electrons. It is these cementing electrons in the radio-active atoms which are thrown off at high speeds as beta particles. It is of interest to note that *atoms very seldom contain an odd number of negative electrons,* and that they are more apt to contain an even number than an odd number of positive electrons. This means that *nuclei with an even net positive charge are much more abundant than those with an odd numbered charge, that is the even numbered atoms are much the more abundant.*

How Are Atoms of Odd Nuclear Charge (Odd Atomic Number) Formed?

If the principal complex constituent used in atom building is

the nucleus of the helium atom, that is the alpha particle, and if this always carries two positive charges, and if negative electrons add themselves two at a time, the question may well arise, "How can an atom of odd nuclear charge be formed?" The answer lies in the fact that there exists another particle, similar to the alpha particle, but which consists of three positive and two negative electrons, that is its formula is $(h_3e_2)^+$ and it carries one positive charge, so that any atom which has in its nucleus one of these particles, will have a nucleus with an odd numbered charge. At the present time *we know of no atomic nucleus in which more than one of these particles is present.* We may call this the *nu* particle. It is the nucleus of the atom of meta-hydrogen, which is an isotope of hydrogen, with an atomic weight equal to 3.00, but which has not as yet been found by itself.

In general any nucleus of odd numbered charge has the same composition as the even numbered nucleus with one less charge, except that the nucleus of odd number contains one *nu* particle.

HOW ISOTOPES ARE FORMED BY THE ADDITION OF MU PARTICLES, OR BY THE ADDITION OF HELIO GROUPS.

That isotopes exist was first discovered by Soddy, who found them among the radioactive elements. What are isotopes? The isotopes of lead act the same as lead in all chemical actions, and also have the same melting points, as found by Richards, and the only known difference of any considerable magnitude, is that the atomic weights are not the same, but differ in steps of two. Since the atomic weights are different and the atomic volumes the same, the densities are different.

Five years ago I developed a theory according to which all of the *actual atomic weights on the oxygen basis* are very close to whole numbers. When the atomic weight given in the atomic weight tables differs much from a whole number, this indicates either that the determination is inaccurate, or that the element is a mixture of different isotopes of the element. Thus chlorine, according to the tables, has an atomic weight equal to 35.46, while my theory gave 35.0 as the atomic weight of normal chlorine. With the aid of C. E. Broeker, W. D. Turner, and T. H. Liggett, I have had diffusion experiments carried out on chlorine for the past five years. The latest work, done together with Mr. Broeker, seems now to indicate that *we have separated the element chlorine into a heavier and a lighter fraction, which shows that it is a mixture of isotopes.* This is in accord with the work of Aston, who, by positive ray analysis, finds that normal chlorine has an atomic weight equal to 35.0, and meta-chlorine has an atomic weight of 37.0.

In general, isotopes are formed by the addition to the nucleus of the atom of the element which has the lowest atomic weight, one mu group, or the group $h^+_2\epsilon^-_2$. This group is as a whole electrically neutral, so if it is added to the nucleus of an atom, the weight increases by the weight of the 2 h particles, or by 2.0, but the charge on the nucleus remains the same. Now any atom with a positive charge of 17 on its nucleus is a chlorine atom. The formula of the normal chlorine nucleus is $(a_8n)^{17+}$ where a stands for the alpha, and n for the nu group. The formula of the nucleus of the isotope of chlorine is $(a_8nm)^{17+}$. A second type of isotope, known only among the heavy atoms, is formed by the addition of the group $(h^+_4\epsilon^-_4)$, which also has no net charge, and therefore does not change the numerical value of the nuclear charge of the atom to which it is added. This group has the same composition as the helium atom, but differs from it in that all of its negative electrons are in the nucleus, while in helium two of the electrons are outside. We may call this group the *helio* group, to show its analogy to and differences from the helium atom. The helio group is one alpha particle plus the cementing electrons used in cementing it on the nucleus of the complex atom.

The Composition of Light Atoms.

To illustrate the structure and composition of atoms, the composition of the light atoms is given in Table 1.

Table II.

The Hydrogen—Helium—Lithium System of Atomic Structure H=1.0078. He=(4 H)=4.00

	1	2	3	4	5	6	7	0	8	
At. No	3	4	5	6	7	8	9	10		
	Li	Be	B	C	N	O	F	Ne		
Ser. 2	He+H_2	2He+H	2He+H_2	3He	3He+H_2	4He	4He+H_2	5He		
Theor.	7.00	9.0	11.0	12.00	14.00	16.00	19.00	20.0		
Det.	6.94	9.1	11.0	12.00	14.01	16.00	19.00	20.0		
At. No.	11	12	13	14	15	16	17	18		
	Na	Mg	Al	Si	P	S	Cl	A		
Ser. 3.	5He+H_2	6He	6He+H_2	7He	7He+H_2	8He	8He+H_2	10He		
Theor.	23.0	24.00	27.0	28.0	31.00	32.00	35.00	40.0		
Det.	23.0	24.32	27.1	28.3	31.02	32.07	35.46	39.9		
At. No	19	20	21	22	23	24	25		26	27
	K	Ca	Sc	Ti	V	Cr	Mn		Fe	Co
Ser. 4	9He+H_2	10He	11He	12He	12He+H_2	13He	13He+H_2		14He	14He+H_2
Theor.	39.00	40.00	44.0	48.0	51.0	52.0	55.00		56.00	59.00
Det.	39.10	40.07	44.1	48.1	51.0	52.0	54.93		55.84	58.97

Increment from Series 2 to Series 3 = 4He. Increment from Series 3 to Series 4 = 5He (4 He for K and Ca). Increment from Series 4 to Series 5 = 6He.

Note: The simple helium system begins with carbon (= 3 He), and continues with oxygen (4 He), neon (5 He), magnesium (6 He), silicon (7 He), sulphur (8 He), argon (10 He), calcium (10 He), titanium (12 He), chromium (13 He) and iron (14 He).

While both the argon and the calcium atom are built from 10 helium atoms, the nucleus of the argon atom contains 10 alpha (a) particles alone, while the nucleus of the calcium atom contains 10 alpha particles with two negative electrons which serve to bind on one of the alpha particles. These may be called binding electrons.

The composition of the thorium nucleus is expressed by the formula $a_{58}\epsilon_{26}$, that of the nucleus of the uranium atom by $a_{58}h_2\epsilon_{28}$, and that of the isotope of lead which comes from radium as $a_{51}h_2\epsilon_{22}$.

a = the alpha particle, mass = 4.00, and charge = 2
n = the nu particle, mass = 3.00, and charge = 1
m = the mu particle, mass = 2.00, and charge = 0
ϵ = the negative electron in the nucleus.
h = the positive electron.
e′ = a non nuclear or planetary electron, which is not in the outside or valence shell.
e = a non-nuclear electron in the valence shell.
$a = (h_4\epsilon_2)^{++}$ $n = (h_3\epsilon_2)^{+}$ $m = (h_2\epsilon_2)$

TABLE 1.

Composition of Light Atoms.

Atoms of Even Nuclear Charge. Atoms of Odd Nuclear Charge.

Nuclear Charge and No. of External Electrons	Symbol of Element.	Composition of Atom.	Nucleus.	Electrons. Inner.	Valence.	Nuclear Charge and No. of External Electrons	Symbol of Element.	Composition of Atom.	Nucleus.	Electrons. Inner.	Valence.
2	He	He	a	e'_2		3	Li	HeNu	an	e'_2	e
4	Be	He_2H	a_2	$\ddot{e}'_3$	e_2	5	B	He_2Nu	a_2n	e'_2	e_3
6	C	He_3	a_3	$\ddot{e}'_2$	e_4	7	N	He_3H2	$a_3h_2\epsilon$	e'_2	e_5
8	O	He_4	a_4	e'_2	e_6	9	F	H_4Nu	a_4n	e'_2	e_7
10	*Ne*	{ He_5 { He_5m	a_5 a_5m	e'_{10}		11	Na	He_5Nu	a_5n	e'_{10}	e
12	*Mg*	{ He_6 { He_6m	a_6 a_6m	e'_{10}	e_2	13	Al	He_6Nu	a_6n	e'_{10}	e_3
14	*Si*	{ He_7 { He_7m	a_7 a_7m	e'_{10}	e_4	15	P	He_7Nu	a_7n	e'_{10}	e_5
16	S	He_8	a_8	e'_{10}	e_6	17	*Cl*	{ He_8Nu { He_8Nu-m	{ a_8n { a_8nm	e'_{10}	e_7
18	A	He_{10}	$a_{10}\epsilon_2$	e'_{18}		19	K	He_9Nu	a_9n	e'_{18}	e
20	Ca	He_{10}	a_{10}	e'_{18}	e_2	21	Sc	$He_{11}H$	$a_{11}\epsilon_2h$	e'_{18}	e_3
22	Ti	He_{12}	$a_{12}\epsilon_2$	e'_{18}	e_4	23	V	$He_{12}Nu$	$a_{12}\epsilon_2n$	e'_{18}	e_5
24	Cr	He_{13}	$a_{13}\epsilon_2$	e'_{18}	e_6	25	Mn	$He_{13}Nu$	$a_{13}\epsilon_2n$	e'_{18}	e_7
26	Fe	He_{14}	$a_{14}\epsilon_2$	e'_{18}	e_8	27	Co	$He_{14}Nu$	$a_{14}\epsilon_2n$	e'_{18}	e_9

The symbols in italics represent elements for which there are two kinds of nuclei (isotopic). Note that they all lie close together in the table, and that only one of the four is of odd atomic number.

Table II explains the fact which has been so great a mystery to chemists, that argon has a heavier atom than potassium, though it appears before potassium in the periodic table. This is due to the fact that the argon nucleus contains two cementing electrons which are absent from the potassium nucleus. The two cementing electrons bind on an extra alpha particle, so the argon nucleus has a mass of 40 instead of the normal value 36. This is shown even more plainly in Table 1, which indicates that all of the even numbered atoms of higher atomic number than argon, with the exception of calcium, have these two cementing electrons ($_{\epsilon_2}$) in their nuclei.

(*To be continued.*)

WHAT SHOULD THE CHEMISTRY TEACHER KNOW?

By Frank B. Wade,
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The excellent article by C. L. Vestal on "What Should the Physics Teacher Know?" in the February School Science brought us the request that we do something along similar lines for the chemistry teacher. We heartily agree with the broad contention of Mr. Vestal that it is not merely the subject but the community bearings of the subject, the social and civic relationships of the science, that should most concern the teacher.

To be sure the well trained teacher must know his subject, and not merely the more elementary portions of it that he will likely teach, but also much of the more advanced part, which will enable him to see the elementary part in its true perspective, and which will permit him to teach it truthfully, even though not completely.

Having had frequently to make out examination questions to be taken by teachers of chemistry who were candidates for entrance into a large city school system, the writer has been forced to consider what parts of the great field of chemistry the well-trained high school teacher of that subject should have studied. The conclusion was reached, that, in addition to much general inorganic chemistry, the teacher should have had courses in qualitative and quantitative analysis, in organic chemistry and in physical chemistry at least, and further, that courses in physics, and in biology, were almost essential and courses in geology, astronomy, and bacteriology very desirable.

So much for the subject matter that the well-trained teacher of high school chemistry should have at his disposal. He will need it all if he is to properly teach his pupils—not merely the small, well-selected portion of it that the time at his disposal will permit, but also the historical setting, the interrelationship with other parts of the great field of science, the service that the science has rendered and is rendering to mankind, and the applications of it to the pupil's own life and surroundings. It will often take every bit of the above training to answer intelligently and successfully many of the host of questions which one's pupils will ask.

The extended question box of Mr. Vestal's article reminds us of a bit of verse from Charles F. Adams' "Leedle Yawcob Strauss":

He asks me questions sooch as dese:
Who baints mine nose so red?
Who vas it cut der schnoodth blace oudt
Vrom der hair ubon mine hed?
Und vhere der plaze goes vrom der lamp
Vene'er der glim I douse?
How gan I all dese dings eggsblain
To dot schmall Yawcob Strauss?

Any teacher of chemistry of some years' experience can recall many questions that have been proposed by pupils, which are no whit easier of answer than those of Yawcob. In fact many questions put by pupils betray much lack of understanding of the particular situation and much of the teacher's time will be needed in straightening out tangled conceptions of relations before attempting to enlighten the pupil specifically in regard to the matter in interest.

The wise teacher will not always attend to answering questions in class time. Indeed would it not be better not to so attend to them except in cases that naturally lead, or cases that can readily be made to lead, to the theme in hand? May I cite an actual case of recent occurrence to illustrate my point? The class was considering the bleaching action of chlorine water, and the intermediate formation of hypochlorous acid and its subsequent decomposition was the new theme that was to be presented. The chlorine in actual use had been generated by the oxidation of HCl by means of $KMnO_4$. A returned service man in the class, still a bit flighty as many of them are, wanted to know why the chlorine might not better have been made by the electrolysis of brine, saying that that was the way it was made for use in gas attack. The question, while *à propos* as regards the preparation of chlorine, was not in order as regards the functioning of HClO in bleaching, and my first impulse was to turn aside the question, but there was the real live interest of the boy, and also that of the class, in his question, which bore on recent military chemistry, so I quickly shifted my ground, took up his question, explained the primary reaction in the brine cell and then, citing the local case of the laundry which advertised "We do not use harmful bleach, we use nothing but pure water, pure salt and electricity," I explained the secondary reaction that produced sodium hypochlorite in the cell. I next likened this reaction to that between chlorine and slaked lime in the manufacture of bleaching powder, showing that the laundry which made its own bleach and the one that bought bleaching powder were working along closely similar lines, and then I got

back to my original theme by showing that the interaction of chlorine and water, like that of chlorine with sodium or calcium hydroxide, produced both a chloride and a hypochlorite but that in the case of water it was the hydrogen salts, that is, the acids, that were produced. The ease with which HClO might be formed from the metallic hypochlorites, its instability, and consequent oxidizing power, were then taken up and I was back on the track so to speak. Perhaps, had I stayed on the track I should have been in a rut (if that is not mixing metaphors) so may we not then regard as legitimate for answering in class all questions that show genuine interest and that lead toward or may be made to lead toward the topic in hand? Extraneous questions, or questions of interest only to the asker, might well be answered after class. In such cases, if the nature of the question permits, the pupil himself can well do most of the work, in obtaining the answer, whether in the laboratory or with reference works. Moreover, requiring participation on the part of the pupil will test his interest to see if it is genuine and he will get vastly more out of the investigation if he participates in it even though under guidance.

Mr. Vestal remarks of his physics questions that "most of them are not answered in the high school texts, except it be in such a remote and indirect way that no ordinary individual would see the implied answer." Nor are the big questions of life directly answered for us anywhere. Always, whether in the field of research or that of morals, we are forced to seek out and apply the principles that underlie the particular situation. Can we do better for our pupils than to help them not merely to dig out for themselves the desired answer, but to show them how to go about it?

In conclusion, my answer to the question "What Should the Chemistry Teacher Know"? would be, first, enough of subject matter, and of the means of getting it, so as not to be at a loss for necessary material; second, how to discern whether or not questions put by pupils are in order (or may be made to fall in line); third, what is going on in the community that is most related to his subject; he should also know the men who are doing these related things; fourth, and most important of all, the teacher should know how to go about showing the pupil how to solve problems for himself.

For the sake of the teacher who has not been long enough at the game to have accumulated a mass of sample questions,

there follows a list of questions that have been asked, most of them recently, in my own department. For many of these I am obligated to my associate teachers, Miss Dorothy Bowser, Mr. John R. Kuebler and Mr. Joel W. Hadley and to numerous pupils in the department who have had a desire to know the whys and wherefores of things chemical.

1. How can I tell if this is gold (presenting a specimen of iron pyrites)?
2. Why does salt, when thrown on the fire, help clean out the soot in the chimney?
3. How do "vinegar bees" turn sugar into vinegar?
4. How can I tell if this is a counterfeit dime?
5. What is the gray stuff in those long red tin cans that are used as fire extinguishers?
6. What is in a "pyrene" fire extinguisher?
7. Is there any magnesium in that bright light that the street car repair men make where they have a sign that says "Danger, do not look at the light"?
8. Can the chemist make diamonds?
9. What makes soft coal smoke?
10. Why does water put out fire?
11. Why do barns sometimes get on fire when they have improperly cured hay stowed in them?
12. Why doesn't gold tarnish?
13. Is this copper ore?
14. Why is the oxy-acetylene blowpipe flame hotter than the oxy-hydrogen flame.
15. Is this a real pearl? (Or real coral?)
16. Why do they lower burning paper into a cistern or well before going down to make repairs?
17. How do they make the gas for soda water now the breweries are out of business?
18. How did they get so much helium for use in balloons during the war?
19. How does a gas mask work?
20. Is hydrogen peroxide a good antiseptic?
21. Are "synthetic rubies" real rubies?
22. Why isn't gasoline as good as it used to be?
23. Why does the tinner use muriatic acid in soldering?
24. Is ozone good for you?
25. What makes chlorine bleach?
26. What is in the two bottles of the ink eradicator outfit?
27. What is Phosgene and why is it so mean?
28. How does the jeweler test gold?
29. How is it that they use salt both to freeze ice cream and to melt ice on the car tracks?
30. What makes sodium skip around so when you throw it onto water?
31. What is radium?
32. Why burn zinc in a fire in order to remove soot from the chimney?
33. What gas do they use in balloons?
34. Why does an aluminum plate with a soda solution clean silver ware that is kept in contact with the plate?
35. Why does Ivory Soap float?
36. What is the deposit in a teakettle?
37. What is the difference between clinkers and ashes?
38. What is "colorless" iodine? Is it any good as a counter irritant?
39. Why does a furnace smoke pipe rust so in summer?
40. How does "Climalene" soften water?
41. Why do you fill the bottle in the chemical fire extinguisher only half full of concentrated sulphuric acid?

42. Why is cistern water soft and well water hard when they both come from the clouds?
43. Why is lime water good for sour stomach?
44. Why does hydrogen peroxide foam when it comes in contact with blood?
45. How do they make hydrogen peroxide?
46. What is manganese and what is it good for?
47. Why are metals more apt to crystallize in cold weather?
48. What is it that baking powder contains that makes cakes rise?
49. Why isn't rubber acted upon by acids?
50. How is glass made transparent?
51. What causes cement to harden?
52. Why do they always use distilled water for storage batteries?
53. Why is ammonia given to a person when she is fainting?
54. What does the iron, taken as a medicine, do for the body?
55. Why is sulphur used as a medicine?
56. Why is the oxide on iron porous while that on copper and lead is not?
57. Why do some brands of ink turn black after they have been written with?
58. Does dynamite exert an equal force in all directions when it explodes?
59. Could diamonds of commercial size be made with some of the new explosives used in the war?
60. Can dynamite be exploded by hitting it with a wooden club?
61. Would an animal, a mouse for instance, die more quickly in a vacuum or in a chamber having greatly increased air pressure?
62. Why is baking powder used in cake, and soda (with sour milk) in biscuits?
63. Why does the water in ice cream sodas bubble?
64. Why is egg put in some baking powders (although it is not used as a substitute for egg)?
65. What makes the white numbers on a black watch dial visible in the dark?
66. How does water get purified in the soil?
67. Why does copper turn green in the air?
68. What is the chemistry of sour milk?
69. Why is gold used for fountain pen points?
70. What is the white metal on the very tip of a gold pen?
71. What per cent is the solution of acid and water in the storage battery?
72. If the negative and positive wires are connected it will blow the fuses but if the current is passed through a solution of water and acid the fuses will not blow. Why is this?
73. Why does a mixture of hydrogen and oxygen explode?
74. What is the substance that forms on the inside of a teakettle?
75. What is the composition of "Carbonoid" and how does it work?
76. What is the difference between steam and water vapor? If they are the same, why doesn't water vapor condense at a temperature below 100?
77. How are the fusible metals, such as are used in automatic fire sprinklers, made?
78. What is in "Carbona" that prevents it from being as dangerous as gasoline when used as a cleaner?
79. How are "sparklers" made?
80. What makes aluminum dishes blacken when some vegetables are cooked in them?
81. Why does salt make a flame clearer?
82. Why is mercury, rather than something else, used in most thermometers?
83. Why does soap lather when water comes in contact with it?
84. How can pewter be cleaned?
85. Why do they put sugar in soap?

86. Why do people put tin cans in the furnace?
87. Why do butchers and refrigerating plants use ammonia?
88. How does salt help to make things freeze?
89. Is pewter a mixture of substances?
90. If hydrogen gas is lighter than oxygen gas why can't it be separated in a bottle the same as a liquid that is heavier than another?
91. Why does sulphuric acid eat up zinc and not lead?
92. Why do not the wires in an electric light melt?
93. What becomes of the weight after a piece of wood burns? The ashes weigh much less than the wood.
94. Why does mercuric oxide return to mercury with oxygen all around it?
95. Why does water bubble when it boils?
96. What is "smelling salts"?
97. When butter stands for any length of time, what makes salt collect on its surface?
98. What causes soda, when put in sour milk, to bubble up?
99. What makes cream when churned turn to butter?
100. Why does bluing turn clothes white?
101. When canned goods spoil what causes the can to bulge?
102. When milk sours and water comes to the top what is the cloudy substance that is formed at the bottom and why does this substance separate from the water?
103. What is in chocolate that makes people fleshy?
104. Why is it that to take iron as a medicine will turn your teeth dark?
105. What is in a lemon that will take stains out of clothing when other methods fail but still without eating it?
106. What is it in shoe polish that makes your shoes shine?
107. What makes soft water soft and hard water hard?
108. Why does gasoline evaporate more readily than water?
109. When bread moulds is it the same kind of action as when iron rusts?
110. What is the difference between hard and soft soap?
111. What does our city gas contain that makes it poisonous?
112. Why do some articles fade when exposed to the air and sun?
113. Why does hot water dissolve soluble substances quicker than cold water?
114. Why does sassafras tea thin the blood?
115. Why is plate glass green?
116. Why does oil rot rubber?
117. What is there in the exhaust of a gasoline motor that is poisonous?
118. Why does putty get hard when standing a long time?
119. Why does rubber become weak after a long time?
120. Why does old paper turn yellow?
121. How does putting an agate in lard take the moons out?
122. Why does salt make whitewash stick?
123. What is the difference in the constituents of colors that fade and those that do not?
124. Why is a gas flame blue?
125. Why does heat restore life to a battery?
126. Why does salt become lumpy after standing for awhile?
127. Is there any way water could be mixed with oil?
128. What is there in an indelible pencil that will not erase whereas a lead pencil mark will?
129. What is there in peroxide that bleaches hair?
130. Why does the blood look blue in your veins?
131. What is the green substance that forms on the end of a water faucet?
132. Why is it that some matches will strike anywhere while others have to be struck on the box?

133. Why is it that onions cause gas to form in the digestive organs?
134. What is it in ether and chloroform that makes people go to sleep?
135. What is it in gasoline that makes it clean garments?
136. What impurities are in water that makes it impossible for use in storage batteries?
137. What is milk composed of?
138. What makes cement become hard when mixed with water?
139. What is there in gasoline and alcohol, and in anti-freeze mixtures that keeps the radiator from freezing?
140. What is there in carbontetrachloride that makes it put out fires?
141. How do automatic gas lighters work?
142. How do the gas lighters that have a round file, and a piece of metal to be rubbed on the file, give such hot little sparks so easily?
143. What is the best way to change hard water to soft? Is there some safe chemical that can be used at home?
144. How can one tell whether such things as "Dutch Cleanser," "Bon Ami" and washing powders are injurious?
145. Why does hot fudge sizzle when vanilla is put in it?
146. When a gas explosion occurs in a house why do the windows sometimes fall in instead of out?
147. Why is soot rather than diamonds (both of which are carbon) formed from the incomplete combustion of coal or oil?
148. Why does guncotton not explode when a lighted match is applied?
149. Why does the carbon in an old fashioned electric light not burn?
150. Why do "Lux" flakes not shrink woolen fabrics?

FUNDAMENTALS IN METHOD—OLD AND NEW.[1]

By Charles J. Pieper,

University High School, Chicago.

Obviously the scope of the subject assigned to me for discussion today is too great to allow a detailed consideration of the many important phases of methods in teaching secondary chemistry. It is necessary therefore that only a few outstanding developments in our method be considered. While discussing these I shall attempt to include the various points mentioned in the committee's questionnaire. From a consideration of these developments we shall find certain valuable suggestions which, adapted to our present teaching, will insure for our students a more permanent interest in chemistry, a more thoroughly scientific study of the subject, and a more economical and profitable use of their time spent in the laboratory and class study.

With the permission of the chairman I shall reverse the order of that part of the topic for discussion which reads "New and Old" and consider (a) The Early Lecture Method, (b) The Laboratory Method and Its Abuse, and (c) The Present Method, with suggested changes.

The Early Lecture Method.

If we accept the statement in many recent articles on the worn

[1]Read before the Chemistry Section of the C. A. S. & M. T. Lake View High School, Chicago, Nov. 29, 1919.

topic "Decline in Science Enrollment" we agree that the popularity of our subject has waned. Undoubtedly one of the factors in the decline is the loss of interest which the study of chemistry has suffered. This is chargeable to the present formal manner with which we present the abstract subject matter.

In the earlier days chemistry was not taught better, considering the many values which accrue from a thorough study of the present courses, but it was taught in such a way that the student's interest was fostered and maintained. This living interest resulted because the student was not burdened with a tremendous number of unrelated facts and details, because the subject was less extensive, and because what was done was done so thoroughly that the student saw clearly the interrelationships of the parts, and the relation of his study to his everyday experiences and to the place of chemistry in the general progress of the day.

Perhaps there are a few in this group who were fortunate enough to gain their first view of chemistry through the lecture method. I say fortunate, even though I am conscious of the many shortcomings of the course. The enthusiastic teacher, "brimming over" with chemistry, clarified his careful discussion with simple demonstrations and with practical applications. As carefully was the student led to see the major relationships, using only such facts and observations as were necessary to cause the concept to be "clear as a crystal." The lectures were informal and always related to the everyday experiences of the students. There was no hurrying through the course in order that sixty-two experiments and 348 pages of the textbook might be completed in the 36 weeks of the school year. The student was not lost in a mass of unrelated observations, terms, facts, symbols, formulas, theories, equations, and laws such as we attempt to wade through in so many of our first year courses today. The course was intensive and in the end the student was able to see it as a continued story with each chapter in its proper order and setting.

Of course, the lecture method had its disadvantages. It was a second-handed method of study. Slower students did not thrive on the predigested knowledge administered in predetermined doses. They were not gaining "first-hand" those invaluable results which are acquired through individual experimentation. It was not the natural method of self education. Moreover, chemistry was rapidly growing and demanded a more extensive course.

But, to repeat, through such course, no matter how many and how great the shortcomings, was developed a projected permanent interest, a spirit of thorough scientific study, and a feeling of satisfaction in something thoroughly done. Such results built the foundation for continued progress and enthusiasm in the subject.

THE LABORATORY METHOD AND ITS ABUSE.

Out of the shortcomings of the lecture and the later textbook method arose the demand for laboratory study. Since the first laboratory was established at Harvard, in 1846, every college and practically every high school has followed Harvard's example. The subject had developed so rapidly that selection from a tremendous field of concepts and topics was necessary. The colleges made the selection, outlined the laboratory experiments and handed down the organization to the secondary schools. Important principles and theories were so numerous that they usurped the major part of the course and the high school pupil found himself in the laboratory, much of the time, attempting to verify the deductions of the mature scientists.

The laboratory work grew and grew. The stockrooms were piled high with apparatus necessary to establish this or that principle. In fact, every principle or concept, it seemed, must be learned in the laboratory, no matter how difficult or how dangerous the experimentation necessary. No account of economy of time was taken. Worse still, no serious attempt to relate the laboratory work to the larger topic or problem was made. The laboratory work was, and still is, in some places, formal, even to the distribution of chemicals. Added to these faults the laboratory and class work were separated, as if they were two distinct phases of chemistry instruction. Two years ago I visited a school where the chemistry teacher told me that he no longer used any textbook or reference book since he believed that the laboratory method was the only method to be used in studying chemistry. Luckily for his students he was a thorough student of chemistry and was able to give them in discussion much that is found in the average textbook. Allow the inexperienced teacher to teach chemistry in this way and you insure even poorer results than are obtained by the textbook method with no laboratory work.

From one extreme to the other the pendulum has swung. The picture is not too dark, I am convinced when I visit various classes in our high schools. Too frequently little consideration

is given as to the best method of presenting the particular topic for study. Perhaps the demonstration method would save much time and in the end the student would have a clearer concept than when he attempts aimlessly to discover for himself the all important truths. Perhaps the problem could be more effectively solved by the use of the textbooks or the reference library. The particular case must determine the method.

The Present Method, with Proposed Changes.

Now the pendulum is swinging to the halfway mark. There are fortunately, many teachers thoroughly enough versed in methods of instruction who see that a combination of the good qualities of the various methods affords the most effective and profitable training in science. These teachers are not carried to extremes; they are conscious of the needs of boys and girls and plan their units of instruction accordingly. Units of subject matter are a secondary consideration. Their first consideration is: How can I most effectively, economically, and thoroughly teach my pupils to scientifically solve the problems which arise in their out-of-school experiences or which develop in the previous study, and to see clearly the relationships of the various problems so that they will gain a chemical and scientific point of view?

The method which they use is in many respects the true research method and as such is a combination of the good qualities of the lecture method, the demonstration, the individual experimentation, field excursion, reading, consultation with authorities, and class discussion. It is, in a word, live chemistry.

This does not mean that every problem will proceed through all of the above steps. It does mean that the problem will be classified by the teacher as of this or that type for which type a certain combination of methods will be employed. It means that we will begin to study the problems and concepts in such a way, through experimental teaching, that we will be better able to know which methods yield the greatest returns for the time spent. On this question we need experimental evidence, just the kind of scientific evidence which we insist our pupils shall have before they arrive at a conclusion to a problem. The means of approach cannot be decided upon by a general questionnaire. The fundamental concepts and topics must first be established and then must follow experimental teaching and careful testing of results.

The course in chemistry will be a course of solving chemical problems, of establishing chemical concepts. It will be a thoroughly scientific course. The problems will be presented or motivated through a discussion of past experiences, assigned reading, informal lecture or demonstration. The means of approach which arouses the greatest desire to solve the problem will be chosen. It will often be the most common practical application of the principle or the strange phenomenon observed by the pupil. The pupil will be brought face to face with a problem. A challenge to his ability will result. In a true research way he will attempt to gain such evidence or information as is required to solve the problem. The larger problem, or project if you wish, will be inclusive of many smaller problems and topics. I recall an illustration from my own classes which will help to elucidate the point. During a short discussion on fire, as a type of chemical change, one of my pupils asked, "Why do you blow a match to extinguish it, but blow a fire to make it burn?" I jumped at the opportunity offered, and before we had successfully answered the question, we had studied oxygen, requirements of combustion, the percentage of oxygen in the air and several related topics and applications. Always the problem was with them, and through its motivation they were able to relate all of the smaller problems and topics. And here I should agree with the questionnaire which suggests that the larger units or problems should be inclusive of many smaller topics. It is through such organization and method that pupils see the larger relationships involved.

Once the problem is clearly before the pupil he will eagerly seek the evidence necessary to answer it. The evidence will be gained by demonstration, experimentation, reading, consulting authorities, and in any other way possible. Here, again, there is no set rule. The concept or topic or problem will govern the procedure. It is wholly doubtful if we can justify sending the pupil to the laboratory every time evidence is needed. I am sure that we cannot justify the individual experimentation which is so commonly carried on without a clear purpose in the pupil's mind. I feel equally certain that the pupil should often know without laboratory directions what he must do and how he must do it. Pupils waste an enormous amount of time aimlessly experimenting because there are so many experiments to be done in a year and because the detailed directions ask him to do this and that.

My contention is not against the present laboratory work in general. It is against laboratory work done without a definite purpose, done unintelligently, and done when assigned reading or a demonstration would yield the evidence required in less time and far more certainly.

Following the gaining of the evidence, yes, during the process, must come frequent short discussions. How often our pupils come to us during the laboratory period, or immediately following, with the question, "When are we going to talk about this to find out what it is all about?" Just the other day two pupils asked me that very question at the close of a laboratory period on the reactivity of metals, when I had supposed that they were clear in the purpose of their experimentation. And now we are ready for additional evidence and information. Where shall we go for it? Any place and every place where we can find it. First, to the definite assignments in the text books and library books; second, to the industry or other actual application; third, to charts, illustrations, exhibits, fourth, to pamphlets of information from industries, to state and city department reports, and to government bulletins; fifth, to home projects; and so on to any other source. And happy may the teacher be if during his years of service he has collected and has had his pupils collect such supplementary materials. His laboratory is a real workshop, a place for research on problems that are just as real to the pupils as is a research problem to the specialist.

But, I hear, what about the time necessary? There is but one answer to this. Have your materials so well classified and so well indexed that they are readily available. In saving time by a judicious choice of method you will do the work so thoroughly that the results will justify the procedure. It is surprising how many facts and concepts will be gained if this problem solving attitude is ever present. After all it is through thoroughness in study that the scientific method is correctly inculcated, and that is the greatest result which the student can acquire.

What will be the pupils' part in such a program? He will keep a comprehensive notebook, not a laboratory notebook only, but one which contains much more than his observations in the laboratory. Such a notebook as has been commonly prepared by my pupils is of little value. The experiments are not related; there are no connecting links. The notebook neither represents the course in chemistry nor is it of use in review. Rather than a laboratory notebook he will keep a chemistry

course notebook. This will contain a summary of the discussion in class, a statement of every problem studied, complete notes on every experiment, whether class demonstration or individual, outlines in statement form, or compositions, on all important required reading assignments and analytical or diagrammatic drawings whenever these will serve to make clearer the descriptions. There will be detailed reports on major topics.

In addition, the notebook will include a list of all new scientific terms met in the course, with a short concise statement of the meaning of the term, a table which gives the chemical name, formula, and common name of every chemical studied, a list of all equations used, and a statement of all important laws and theories considered.

All of this work will be carefully done in ink, in acceptable English form and formulated in the words of the pupil as far as possible. The pupil will have, at the end of the course, a notebook, which for him is a better source for study and review than any textbook. On the part of the teacher this will mean a definitely planned course, outlined for the pupil's guidance.

If I have indulged in glittering generalizations, it must be granted that they have been made upon the basis of experience. There is little experimental evidence in the modern sense of the term. Experimental teaching with carefully devised testing of the results must come. This I consider the greatest possible contribution of such a group as this. If we will but select a certain set of fundamental concepts and topics or problems and then try experimentally the various combinations of methods, we shall be able to verify the effectiveness of the best method.

Professor Edwin Oakes Jordan, Chairman of the Department of Hygiene and Bacteriology at the University of Chicago, has been elected a member of the International Health Board of the Rockefeller Foundation. The work of this board has been largely devoted to the study of hookworm diseases and the best means of preventing this infection. Much work has also been done and is still in progress on malaria, particularly in the southern part of the United States. The tuberculosis emergency in France during the Great War and public-health education in South America and other parts of the world have also received especial attention from the board.

CALCULATION BY GEOMETRY OF ASTRONOMICAL DISTANCES.

By Joseph V. Collins,

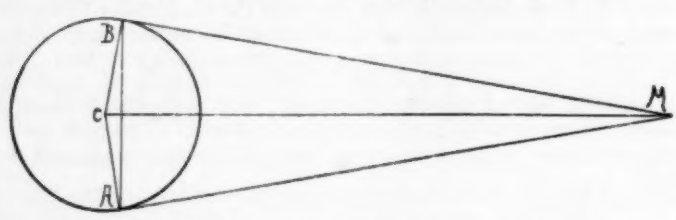
Normal School, Stevens Point, Wis.

One of the most marvelous feats of the human intellect has been the calculation of the distances between the various heavenly bodies. The difficulties in the way were terrific both as regards plans for the calculation and the making of the necessary instruments and measurements with them.

A variety of courses have been followed to attain the end sought, but to give a satisfactory glimpse of how the problem was solved, four steps in the solution will be explained.

1. Measuring the size of the earth: By measuring arcs on the land surface of the earth, noting the angles they subtend at the center of the earth, it is easy to find the circumference. Then from the circumference, the radius is found.

2. To find the distance from the earth to Mars when they are closest together, Mars being then directly opposite from the sun:[1] Let A and B be two points on the earth having the same longitude and far apart in latitude, and M the position of Mars described. Astronomers at A and B measure very accurately angles MAC and MBC, C being the center of the earth. Since B and C are known points angle ACB is known, being the sum of the N latitude of B and S latitude of A, and the angle ABC is known, since when two sides and the included angle of a triangle are known the triangle is known. By plotting triangle ABC and then angles MBC and MAC the line MC can be found, which is the distance sought. Trigonometry enables us to calculate unknown parts of triangles ABC, MAB, and MAC much more accurately than can be done by plotting to scale.

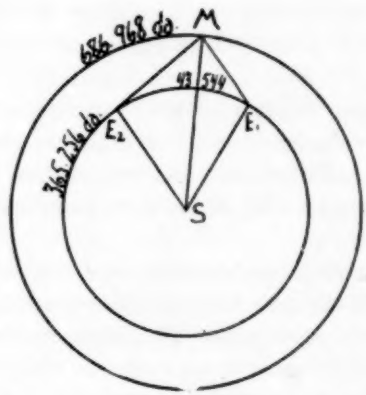


3. Measuring the distance from the earth to the sun: Clocks are made which keep time for long periods with amazing accuracy, and which can be rated or kept in good time by astronom-

[1]This method is of only theoretical applicability to Mars, though it has been applied to the moon.—Ed.

ical observations. Also by observations the time which it takes the earth and Mars to make revolutions around the sun can be found with great accuracy. The earth makes a revolution in 365.256 days and Mars one in 686.968 days.

In the figure below, let S represent the position of the sun, the inner circumference the orbit of the earth, and the outer that of Mars, and suppose M is a position of Mars at two dates 686.95 days apart, and E_1 and E_2 the respective positions of the earth at the two dates named, E_1 the first and E_2 the second. Notice the earth has made less than two complete revolutions by 43.544 days.



When the earth is at E_1 the angle SE_1M is measured in the plane of the ecliptic, that is, the difference of longitude of the sun and Mars is measured. Similarly when the earth is at E_2 and Mars is a second time at M, the angle SE_2M is measured.

Taking SE_1 any convenient length as the unit of measure, suppose SE_1ME_2 has been constructed from the measurements obtained, angle E_1SE_2 corresponding to 43.58 days. Measuring SM with SE_1, as measuring unit, let $SM = m\times SE_1$. Then, if *d* is the distance in miles from the earth to Mars when Mars is nearest the earth, as shown in the figure,

S——————E—————M

$m\times SE_1 - SE_1 = (m-1)\times SE_1 = d$, whence $SE_1 = d/(m-1)$, or distance from the earth to the sun.

4. To find distances to fixed stars; Parallax: Astronomers have found that some of the fainter stars are immensely farther away than some of the brighter fixed stars. They make use of this fact to find the distance to the nearer stars.

Let E_1 and E_2 represent two opposite positions of the earth in its orbit, S_1 a near star and S_2 one vastly farther away than the first. Suppose E_1, S_1, and S_2 are in a straight line when the earth is at E_1. S_1 and S_2 being so-called fixed stars, it is clear they will not be in line with the earth when it is at E_2. The figure shows that angle $E_1S_1E_2$ (which is called the *parallax* of the star S_1, with reference to the earth's orbit) equals the sum of angles E_2 and S_2. Now because S_2 is such a vast distance from E_1 and E_2,

its angle is so small that it can be called 0°. Thus, $S_1E_2S_2 = E_2S_1E_1$. Now if E_1S_1 and E_2S_1 are chosen so that they are equal, angles $S_1E_1E_2$ and $S_1E_2E_1$ are each equal to $(180° - E_1S_1E_2)/2$. But E_1E_2 is the known diameter of the earth's orbit, so that here again we have two angles and the included side of a triangle given to find the other sides. This calculation can be made by drawing the figure to scale, or as accurately as desired by trigonometry.

Note. Various other geometrical methods of calculating the distances apart of the heavenly bodies give results which agree well with those obtained by the methods here outlined. The distance of the earth from the sun can be found also from the known velocity of light, and the result so obtained agrees with the others. It is idle to believe that such agreements could exist and the measurements be in error, except by a negligible per cent.

Note. Professor George C. Constock of the Department of Astronomy, University of Wisconsin, who read the manuscript of this article, pointed out, as the writer had supposed, that astronomers would prefer to depend on Kepler's law for the value of m rather than on the geometrical measurements obtained in 3 above. However, it can be said that the method described in 3 is actually used, and serves the present purpose better than to use Kepler's law, that "the squares of the periods of the planets are proportional to the cubes of their mean distances from the sun."

A TEXTBOOK FOR GENERAL SCIENCE.

By Neil E. Gordon,
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In discussing a textbook for general science in high schools, I shall touch upon the following three points:

(1) Justification for a textbook;
(2) Content;
(3) Method of presentation.

Justification for a Textbook.

It seems to me that the opinion is altogether too common that each teacher of general science should make his own course and adapt it to the needs of his pupils. Theoretically this is fine, but it is not practical from the administrator's, teacher's, or pupil's standpoint.

I am quite in sympathy with the administrators of schools, who are becoming impatient with the indefiniteness of general science. How are they to give the proper perspective to a subject in the curriculum if that which is in the course is going to be determined entirely by the teacher?

It may be feasible for teachers in model schools or universities with allotted time for creative work to devise wonderfully adapted courses in general science, but how about the teacher who is teaching six periods a day for five days in the week? I am sure that during his vacant period he has something else to do besides devising work for the following day in general science.

Then there is the novice and faddist. They mean well, but their efforts, as a rule, are tending to make general science very indefinite and leading the administrators to demand with a great deal of justice, "What do you mean by general science?"

The students who are at the mercy of faddists, novices, and inadequately prepared teachers are surely not getting as good training, if they are being taught without a book, as they would from a correctly prepared book.

As a rule, if a teacher has specialized in one subject, she will feel that this science is better for the student than any other, and hence her course will become very one-sided. All sciences have their halls of charm, beauty, and usefulness, for the student, and the reason that we cannot see it, is that we have not taken the time or had the inclination to push open the doors that lead into these wonderful halls in other sciences.

High schools cannot hope to get the credit that they should for

general science until the period of fluctuation has passed and the high school has defined, at least in part, just what they mean by general science.

Content of the Course.

It seems to me that C. M. Howe, of Hughes High School of Cincinnati, Ohio, has tackled this "content problem" in the right spirit. He sent out a questionnaire including a list of topics for general science. The teachers were asked to mark these topics as Fundamental (F) or Supplementary (S), according to their belief that they were esssential to the subject or only possible value as optional material. You may find these results scored up in the reference cited.[1] The concordant fashion in which the teachers responded was rather significant. Could not each State profit by this advancement made by Ohio? And by means of State Teachers' Associations, each State could soon fix upon a standard minimum requirement. I say minimum requirement, for I feel that there should be a certain latitude of freedom for the teacher to put in local coloring. Such action would standardize the course while making it sufficiently adaptable to the needs of the community, and allow the teacher to develop any pet subjects to a safe extent.

Now, when the content of the course has been decided, the textbook should be written to envelop this minimum requirement so that it will make it as easy as possible for the teacher, while giving the student the maximum development.

Method of Presentation.

The method of presenting this minimum content will never have its maximum value to the student if books are written up the way that most of the general science books are today. The very way that they are written demands that they be taught by a textbook-memory method, where all projective or laboratory work of the student is given the subordinate position of merely illustrating the text, and any questions which arise are answered by reference to the text or from memory. There isn't any question that such a method is highly artificial, affords little training and tends to spoil the keen observation and exact reasoning of the student. On the other hand, I do not believe that the other extreme or project method, as commonly understood, is practical, i. e., where the student is given the project and required to work it out alone except from hints given by the

[1]School Science and Mathematics, Vol. XIX, p. 248-255.

teacher. The average teacher either gives the student too much or too little help. Either is fatal to ideal teaching.

One solution of this problem is this. Write up a book on these minimum requirements so that it will be possible for the teacher to present the subject from a projective method standpoint without working herself to death, and at the same time saving the scientific mind of the student. The book should contain such information, in the form of hints and questions as far as possible, so that the student will receive just the right kind of help and just enough so that the average student may carry out his project intelligently and without loss of valuable time. This information should have the following aim: to give the student a clear insight into the purpose of the project; and to throw light on any complications that are beyond the range of the average student. It should also contain any information that is necessary for a continuous understanding of the project, and lastly it should contain reference to some literature upon the project under consideration.

The major project may be broken up into minor projects, and each minor project may be done only by one student or a group of students. A major project as "Matter and Force" might include the minor projects gravity, weight, density, inertia, capillarity, etc. These should be put in the form of questions, as:

1. Is air matter?
2. Why does a candle burn?
3. Why do bodies fall to the earth?
4. Why does water rise in a towel?
5. How does a separator separate cream from milk?

Space should be left in the book to tabulate all observations and answer all questions so that the project will be a continuous story. To illustrate briefly:

Project: How does a separator separate cream from milk?

Apparatus: Pail (about ten quart), heavy cord, water, sawdust, separator.

Is the density of cream greater or less than that of milk?

What daily experience gives you the reason for your answer?

In the preliminary study of the project, water and sawdust will be used in the place of cream and milk.

Which will you have represent the cream and which the milk?

Give reason for your choice.

Place about two quarts of water in a ten quart pail and suspend it by means of a heavy cord so that it will be free to swing. Place some sawdust on the surface of the water. Turn the pail until the cord has acquired considerable twist. Now, let go of the pail and allow the cord to untwist.

What position does the water take in the pail?

What position does the sawdust take?

What would be the relative positions of the cream and milk were they subjected to the same experiment as the water and sawdust?

This preliminary laboratory work has put the student in a position to attack his project with intelligence. They are now ready to suggest how cream is separated from the milk in a cream separator. If this experiment is carried on in the city where the children cannot see a separator in actual use on a farm, it would be possible to have them examine one at some farm implement dealer's. It would be much better to loan one and have it at the school. Then all pupils who are interested might glean some knowledge of such an apparatus. Some of the pupils should be asked to demonstrate and describe the cream separator to the class. The Babcock butter tester will almost always come up with the cream separator. One student might be asked to make a test with this apparatus before the class.

At this time it would be quite fitting for the teacher to do some demonstrations on centrifugal apparatus, and to enlarge upon the meaning of centrifugal force.

The project may end here, for you have accomplished all and more than you started out to find, but in the purposed book you will find after this project, references in literature about the centrifuges in which crystals of sugar and salt are dried in the process of refining, and also references to explain the fact that planets revolve about the sun in nearly circular orbits because of the combined influence of gravity and inertia. The project should be enlarged upon by the students reading as many of these references as time will permit.

When the material gathered from the laboratory, textbook, demonstration exercises of the students and teacher, from the pupils' observations of commercial apparatus, and from reading references, has all been finished and digested, the student should be asked to write up a report on the project in order to clarify his ideas. The day that these reports are handed in, should be given over to the discussion of the project as a whole. The recitation should be the means of unifying, expanding, and illustrating what the pupil has learned in an experimental, vital way.

I feel confident that, if general science teachers would decide upon this minimum requirement, and a textbook were written up on these requirements by a good high school man or committee of such men, along the lines suggested above, it would make it possible for teachers with their crowded schedules to carry out this project method, which, undoubtedly, is the best method before the teaching world today.

THE GENERAL SCIENCE OF THE FUTURE.[1]

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The future of general science can only be written in terms of present and immediately past tendencies. If these prove unreliable there is no other guiding principle. General science in the past has evidenced three stages of growth. The first courses and texts were of the encyclopedic or hodge-podge variety; seemingly little more than an assemblage of condensed texts of a half dozen special sciences, and of doubtful value from the standpoint of arrangement of materials, but, at the same time, excellent handbooks for beginning students. This sort of teaching was super-saturated and committed to the false doctrine that the differences between ninth grade pupils and college students were purely quantitative in that a process of condensation and elimination of a few difficult topics would produce suitable high school courses from existing college texts.

The second chapter in the evolution of the general science course was the formulation of what might be called "unity" courses. This was a reaction to the charge of soft pedagogy and is characterized by the efforts to secure unity by building in the diverse materials about some one special science as a matrix. Some schools and most textbooks of general science at the present time show such biases toward physiology, physics, agriculture, etc., as the case may be. Perhaps this type of course was most prevalent up to the year 1918, and is by no means completely eliminated at the present time.

The last stage in this development is not so easily given a suggestive name. Perhaps, the term "Environmental Problem Courses" is most satisfactory. This type of course has definitely thrown all logical organization to the winds and is attempting to substitute a series of problems or projects bearing directly upon the school, home, and community life, from the standpoint of practical applications rather than "fundamental principles." This is the most comprehensive attempt in the history of science teaching to make the principles of science subservient to and somewhat incidental to the applications of these generalizations. Moreover, this practice has forced a complete reversal of the order of presentation of materials and by very nature of the situation *has made inductive teaching an enforced reality.* If general science has done nothing more it has made a very considerable contribution to the advancement of inductive methods in

[1]An abstract of a paper read before the Science and Mathematics Section of the Oregon State Teachers Association, Dec. 31, 1919.

the classroom. This point leads at once to the central theme of this paper—viz., *the future of general science is very largely a question of its ability to devise a suitable method.* The question of content, although not to be neglected, is of minor importance since general science cannot hope to present much content that is new, quite on the contrary much that is valuable must be omitted, but what might be done is that such content could be organized and presented in a more suitable form from the standpoint of pedagogical requirements. It is not at the door of the factual aspect of science materials that the blame for present unsatisfactory conditions must be laid, for to do so would practically be a denial of the educational values of science teaching, but, the practice of introducing eighth and ninth grade children to a technical, formal, analytical, brass-plated, electrically controlled, agate-bearinged sort of science must be deplored. It has too often come to be a case of the child losing sight of the forest for the trees. These things are the conveniences of science, not the realities. They are the man-made aspects of science. They serve to confuse, not to educate, and they often forget completely the main thing in the whole scheme of education—the mind of the child. Technique, valuable as a means, must not be substituted in educational beginnings for psychological organizations more in harmony with actual mental processes in the pupil.

This brief critical discussion opens the way to the more constructive suggestions of the future.

THE CHARACTERISTICS OF THE GENERAL SCIENCE OF TOMORROW.

If the tendencies of the present and immediate past are to be relied upon to continue, the general science of the future will be pretty sure to involve a method whose broad outlines will be characterized by widespread use of certain principles, which can here be grouped as five in number.

1. Wider use of the inductive method with the added possibility that the laboratory approach to all topics will be religiously adhered to.
2. The selection of immediate environmental problems will be the chief criterion in the determination of the content of such courses.
3. The general science course will probably be pushed back into the junior high school grades and may in cases be expanded to cover two or even three years about grades 7-9 inclusive; thus articulating with the nature study of the grades and the purer science of the higher years.
4. The general science of tomorrow will probably be problem or project science to a large extent.
5. The results obtained in general science teaching will be subjected to measurements by the use of standardized tests similar to those used in elementary school practice.

Discussion.

All of the foregoing principles are already present in some degree in the teaching of general science, although usually not all in any one school, some specializing in one, others in another. The task is to assemble these tools into a consistent method and a few suggestions as to how this is to be done will be taken up in order.

I. Inductive, Laboratory Method.

This has long been the ideal in all science. Practically everyone is agreed upon the superiority of such over pure text book or pure lecture methods, although, rather curiously, such a superiority has never actually been proved. Apart from F. C. Ayer's[2] study of the psychology of drawing with special reference to laboratory drawing and Edward J. Maynard's[3] comparative study of the relative efficiency of the book, lecture, and combination lecture—demonstration method, little experimental evidence exists. So even the laboratory method rests chiefly upon consensus of opinion. However, the fact that no absolute experimental justification of this method has ever been made is probably not to be seriously considered as casting doubt upon the superiority of inductive laboratory practice, rather, showing a curious anomaly in that science has never thought to apply its own ideas of procedure to its own internal problems.

Granting the superiority of the inductive laboratory method, there remains a practical situation to be considered, namely, that in spite of the fact that it has generally been assumed that this method is in widespread use, it is very doubtful whether true inductive laboratory teaching has ever prevailed to any considerable extent. Doubtless most of you will take issue with this bold assertion, but the actual conditions obtaining in the vast majority of schools are such as to place the most serious limitations upon any very extended use of this ideal of method. Leaving aside the very open question as to whether inductive thinking is psychologically possible over any sustained period as a question for pure psychology to answer when it may be able, there are certain purely mechanical difficulties in the administration of most of our schools which effectually block our efforts at inductive teaching. In the high schools of this state, with very few exceptions, the laboratory periods are fixed at certain

[2]Ayer, F. C.: The Psychology of Drawing with Special Reference to Laboratory Practice, 19[illegible], Warwick and York.

[3]Maynard, Edward J.: Teaching Elementary Science in Elementary Schools, Pub. 13, Div. of Reference and Research, N. Y. City Schools.

days of the week for reasons connected with the scheduling of the school program. This practically severs any close connection between the work of the classroom and that of the laboratory. Of course the text work can, in general, precede or follow the experimental exercises of the laboratory at the option of the teacher, but it is decidedly doubtful whether any teacher can ever give a truly organic connection between the two elements of instruction in opposition to this administrational handicap. Nor is this point a petty criticism, for the very nature of the inductive-laboratory method demands that *all* laboratory work on a given topic *must precede* the textbook work. As conditions exist, the best we can do is to develop our recitation work as nearly inductively as possible, while at the same time we are throwing away the best aid to inductive teaching—the laboratory—and falling back upon the much inferior plan of using the laboratory for proving the truth of the principles presented in the class recitation proper. This type of teaching is in reality nothing more than the time-honored plan of the laboratory as a place to test the truths handed out in the classroom—a method which is the exact reverse of that demanded by induction.

The difficulty here is so purely mechanical in the great majority of cases that no adequate excuse can be given for the continuation of a program which sacrifices a good method for administrative reasons. The teacher must be free to decide which days are to be utilized in the laboratory and which in the recitation room. At times, it is desirable that for weeks no textbook should be opened at all and that the entire period be spent in the development of a topic by experimentation in the laboratory. Probably, almost without exception, *laboratory work must precede textbook work in general science.* This means that the plan of double periods for laboratory work must give way to equal periods of somewhat longer length—a demand that is quite in harmony with modern administrative tendencies in that this very thing is coming as a result of the induction of supervised study which, in itself, calls for longer class periods. The advantage of this has been emphasized here and should be utilized by teachers of science as a way out of one serious difficulty.

But there is a second obstacle to be overcome that is more serious. The first was purely mechanical; the second, largely pedagogical... To teach inductively, the textbooks must be inductive in spirit and construction. As far as I am aware very

few textbooks in secondary school science can be fairly called inductive. Some teachers are succeeding in spite of the texts. We hope a good many are. What the facts are cannot be determined. It is a hopeful sign that textbooks are appearing which do develop the subject matter by a procedure working from a mass of applications of a familiar sort to the fundamental principles underlying. This method is rigidly demanded by true induction—not the reverse as characterizes the procedure of most of our texts. Recent books like VanBuskirk and Smith, Hodgdon and Trafton, to confine the discussion to general science alone, are making considerable strides in the right direction. From a nucleus like these, the future is very hopeful, even if these beginnings are still crude and unpolished. These books and a few others of their type lead one to think that there is probably more thought being devoted today to the writing of suitable textbooks from a psychological standpoint, in the field of general science, than in that of any other single science subject. Analysis of a half dozen recent texts has really made me optimistic for the future.

In the University high school, at Eugene, we have made some beginnings in the way of inductive teaching. We have adopted the plan of five equal periods per week with laboratory days falling at the will of the teacher. The subject matter has been organized as a series of fifteen problem topics, each of which involves from three to ten laboratory experiments. All of the last precede any textbook work—and no exceptions are allowed. In this way the first difficulty mentioned above has been completely obviated. The second handicap to inductive teaching has also been overome in part since the course of study does not follow any particular text and hence there is greater freedom of method allowed. The fifteen units follow each other for the most part in related order, although each is an organic unit. The separate experiments are designed so that each contributes one bit of data to the solution of the general problem topic. The textbook work is merely that of supplementing the knowledge gained by actual experimentation and takes the nature of reading rather than study although some time is spent in recitations proper. The readings are in part assigned and in part unassigned. The former are checked up by class recitation, the latter by written abstracts handed in, a minimum limit of ten pages per week being observed. In such a course, the textbook may be highly influential in the success of the work, but it is scarcely a vital element.

II. Immediate, Environmental Problems.

The second characteristic of the general science of the future grows out of the discussion of the preceding one. It is partly a criterion for the selection of subject matter of useful nature and partly a question of suitable method. It is only for the sake of emphasis that it needs further mention. The texts I have just cited illustrate something of what we mean by choosing materials which are correlated with the immediate surroundings and interests of the child. Admittedly far from perfect, each year has brought us nearer to the ideal. Caldwell and Eikenberry were the first to grasp the idea of environmental problems in contrast with formal laws and principles as the point of departure in the study of science. Later came Smith and Jewett, Van Buskirk and Smith, Hodgson, and last, Trafton, an advance copy of which I have brought here today for examination. There is nothing new in the method of these books—it is rather a question of a more extended use of a recognized pedagogical fact, viz., that everyday applications of scientific laws form better starting points than purely hypothetical applications of those same laws. The mystery is here the same as in other points that I have discussed, i. e., when everyone is agreed upon a thing, and we heatedly advocate it at every opportunity, *why don't we do it ? ? ? ?* Instead, we go ahead writing our books as we have always done. It looks suspiciously like the kiss of Judas and that we lack the courage of our convictions. Here, again, I believe that the recent textbooks in general science will gain rather than suffer by comparison with science texts in general.

III. General Science for Junior H. S. Grades.

This, like point one, is largely a question of administrative needs, but concomitant with these are certain deeper and more psychological relations of subject matter and method. With the growth of either the 6-3-3 or the 6-6 plan, there is to be a great need of science instruction through the grades 7-9 inclusive. Geography is finished in modern practice in about grade 6, or 7 at latest, leaving either two or three years without any comprehensive and unified science program. Agriculture and physiology receive a certain emphasis but are a disgraceful example of teaching science by ignoring all scientific procedure in their method of presentation. It is an open question whether such subjects can be considered a success in this position. There is,

therefore, an unfilled space in our science curriculum. The sciences of the senior high school are furnishing a pressure downwards with the special sciences of botany, physiography, biology, zoology, geology, physics, chemistry and physiology all clamoring for a place.

All this in addition to the fact that general science is in its psychological nature suited to adolescent years. Its concrete rather than abstract nature, its generalizations from immediate applications to the laws themselves, its bird's-eye view rather than the logical classificatory treatment of data, and the like, all serve to make general science the proper science for the junior high school. The expansion of the course over 2-3 years will surely follow as a matter of course, and in so doing will tend to eliminate another criticism of the subject, viz., its tendency toward superficialism due to its wide range nature. There will be less need to rush from one topic to another as some seem to think is necessary as if there were some divinely set goal to be reached by the end of the term, in contrast with a few things well taught. In the country school and rural high school, the science will be largely colored by the problems of the farm environment and life. This adaptability of general science to local needs is in reality a source of strength since it is free to conform to the community rather than be bound to follow a formal set of principles and experiments as in biology, physics or chemistry.

Lastly, general science should furnish aid to the junior high school movement to a considerable extent in that exploratory aim of this reorganized school unit which is so committed to vocational guidance.

There is little question that "problem" or "project" teaching is one of the leading questions in the field of methods of instruction today. Originating, perhaps, in the field of the social sciences, it became almost simultaneously a storm center in natural science. Thus far the problem or project has escaped definition, being concealed in a fog of theory and ideals in the camp of the educational theorists on the one hand and lying humbled and bleeding in the camp of the vocationalists on the other. The former would demand standards impossible of immediate attainment, the latter would degenerate the problem into mere pieces of handwork. A problem reduced to the operation of turning out a piece of wood on a lathe, or the like, surely offers little new to methods of teaching as this is almost uni-

versal practice in the manual arts. If there is such a thing as a problem and if it offers educational possibilities, it must present a series of psychological processes which bear a close relation to those nervous activities of creative thinking. In a phrase, the problem, if valuable and a new contribution, must involve the higher thought centers rather than the lower neuro-muscular functions. So much for a fleeting glance at the psychology of the project.

Another point of view is that of John Dewey. The five steps in the thought act of Dewey is virtually an analysis of the problem method as it appears psychologically. Like the preceding discussion I have given, Dewey's scheme offers little of directly practical value in getting problem teaching under way in our classrooms.

Somewhat more concrete is Snedden's attempt at formulating the evolution of the problem or project. He recognizes four stages, as follows:

1. The Question.
2. The Lesson.
3. The Topic.
4. The Project.

1. The question, the smallest unit ever devised, was partly pedagogical and partly logical in nature. It is the most easily used by the unskilled teacher and is best suited to the age of authority and memorization.

2. The lesson was a pseudo—pedagogical unit; being based upon the sheer physical learning capacity of the child. Hence, it largely measures duration of attention, fatigue effects, etc. It tends to be purely arbitrary as, e. g., like cutting off two yards of cloth or one hundred feet of rope.

3. The topic is characterized by some logical relation to some larger unit of subject matter. At the same time it takes account of the limit of the focusing of attention power of the child. It is more suited to inference and processes of reasoning than to memorization.

4. The project is characterized by concrete achievement, thus taking its unity. There is always a clearly forseen end to be reached and the process of reaching that goal must be objective enough to permit of evaluation. It calls for the application of past knowledges and skills together with the acquisition of some views, knowledges and skills. Even in the case of the project, while it is somewhat final from the pupils' standpoint, to the teacher it is a step to some larger goal.

From a biographical viewpoint, there is probably no better illustration of the problem method than that of the life of Pasteur. Starting out with a purely chemical problem in the stereochemistry of racemic acid, he studied successively crystallography, polarized light and rotation effect in solutions, the nature of fermentation, the liquor industry of Belgium, microorganisms, disease, etc., etc., in a brilliant series of projects covering a life time.

We have seen efforts at formulation of the meaning of the project from three viewpoints, the psychological, evolutionary and biographical. The general idea is fairly evident, the exact definition impossible, the application uncertain. Of the five characteristics of general science teaching of tomorrow, this is the most visionary, but perhaps at the same time the most promising. The literature on the subject is fairly extensive but falls sharply into two groups: (1) purely theoretical, (2) practical but falling far short of the ideal. A few textbooks like VanBuskirk and Smith have made a noticeable gain in this direction.

Before leaving the project question, it may be to the point to restate one thought previously mentioned, for the sake of emphasis. The project, whatever it may look like when viewed objectively, is intended to stimulate a certain sequence in thought processes—those usually termed the reasoning processes. This virtually reduces the psychology of the project to that of induction. The difference seems to be of a structural sort, more related to the content concerned in the development of a project, e. g., such matters as the ignoring of formal boundary lines of special science and the concrete, practical product produced incidentally to the play of those higher observational and inferential mind processes. To the writer's mind, the project is little more than a new cloak for the inductive method, but has a new value in that it is applied to concrete achievement rather than over-difficult abstract principles. Such concrete problems of the wiring of a door bell, or the dyeing of a doll's hair and clothing from coal tar products obtained in candy from the corner grocery store, are never chiefly valuable in themselves as a commercial matter, the practicability and concreteness being chiefly useful in that they form a means to strike the responsive chords in the child's thinking. It is for this reason that the problem method will continue to be explored and eventually form a most valuable instructional tool.

V. Standard Measurements.

As Professor Eliot R. Downing, of the University of Chicago, has pointed out in *School and Society* for November 15, 1919, science teachers, rather strangely, have been most loath to adopt the newer scientific methods of measuring results. This is without doubt a part of the conservatism demanded by scientific procedure.

The growth of standard tests is a feature of modern educational progress in many school subjects, although little, comparatively, has been done for high school subjects. A few beginnings have been made, notably the Starch test for physics, although this has not attained as much attention as it deserves. Grier has a range of information test for physiology and zoology, and Downing one for secondary science in general. F. T. Jones devised a test for physics and chemistry, and within the past year Hanor A. Webb and J. Carleton Bell have each attempted tests for chemistry. Lackey and Witham have tests for elementary geography.

General Science Quarterly for November, 1919, has an account of the writer's, "Range of Information Test in General Science," begun two years ago but interrupted by the war. A preliminary standardization of this last is now under way.

Conclusion.

In conclusion, it may fairly be stated that general science has demonstrated the right to further experimentation in our schools, and that the opposition to such courses is gradually dying out as the aims, methods, and results are becoming better known.

For the future, general science seems to have one chance, and perhaps only one chance, viz., its ability to work out a better method of instruction than the special science of the past has produced—a method that I have tried to characterize in five ways as involving:

I. Inductive, laboratory teaching.
II. Selection of materials to form environmental problems.
III. Junior rather than senior high school science.
IV. Project science.
V. Use of standard tests.

THE CHARACTER OF THE ROOTS OF A QUADRATIC EQUATION.

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It is the universal custom of English and American writers on algebra, including such eminent writers as Chrystal and Todhunter, to discuss the character of the roots of the quadratic equation $ax^2+2bx+c=0$, by means of the discriminant b^2-ac. This function conveniently distinguishes equations having real roots from those having complex roots and singles out the case in which the roots are equal, but it fails to indicate cases in which the roots are numerically equal and opposite in sign, or when unequal and of like or opposite signs, or when both roots are purely imaginary, or when one or both roots are zero.

Certain European Continental writers[1] do indeed consider

[1] *Borel, Algebre* 1[er] *Cycle* (Paris, 1905).
Bourlet, Precis d'Algebre (Paris, 1907).

some additional characters after the theorems relating to the connection between the coefficients and the roots of an equation have been established. The additional characters are then derived by considering simultaneously the signs and absolute values of the ratios c/a and b/a in conjunction with the sign of the discriminant. Bourlet tabulates the following cases:

$c/a<0$ two roots with opposite signs	$-b/a>0$, root with largest absolute value $+$.		
	<0, root with largest absolute value $-$.		
	$=0$, roots equal and opposite in sign.		
$c/a>0$	$b^2-ac>0$,	$-b/a>0$, both roots positive.	
		<0, both roots negative.	
	$=0$, each root equal to $-b/a$.		
	<0, no real roots.		
$c/a=0$	one root $=0$, the other root $=-2b/a$.		

Now all these results, besides some others as will be shown, may be easily obtained without the assistance of any preliminary theorems from the character of the function ac/b^2. This function so completely determines the character of the roots of the quadratic that it might be appropriately called the *characteristic* of the roots of the quadratic. As this characteristic varies from $-\infty$ through all real values to $+\infty$ the roots of the quadratic assume in succession all possible characters, that is to say, to each character of the roots corresponds a definite value, or range of values, of the characteristic.

Let us write the quadratic in the form

$$ax^2+2bx+c=0,\ a>0, \tag{A}$$

from which

(B) $$x = \frac{-b \pm \sqrt{b^2 - ac}}{a} = \frac{-b}{a}(1 \mp \sqrt{1-k})$$

where $k = ac/b^2$.

1. $k = -\infty$. Since a is positive, b must be zero and c negative. Then (A) shows that both roots are real, numerically equal, and opposite in sign.

2. $-\infty < k < 0$. Since k is negative, $1-k$ is positive and greater than 1, therefore $\sqrt{1-k}$ is positive and greater than 1, therefore one value of $1 \pm \sqrt{1-k}$ is positive and the other negative. The roots of the quadratic are therefore real, unequal, and opposite in sign, the numerically greater root being positive or negative according as b is $<$ or $>$ 0.

3. $k = 0$. If $k = 0$, $\sqrt{1-k} = 1$, hence one value of x is 0 and the other is $-2b/a$.

4. $0 < k < 1$. $1-k$ is now positive and less than 1, therefore $\sqrt{1-k}$ is positive and less than 1, and both values of $1 \pm \sqrt{1-k}$ are positive. The roots of the quadratic are therefore real and have like signs. They are both positive or both negative according as b is $<$ or $>$ 0.

5. $k = 1$. If $k = 1$, $1-k = 0$, and (B) shows that x has two equal values each equal to $-b/a$.

6. $1 < k < +\infty$. In this case $1-k$ is negative, therefore $\sqrt{1-k}$ is imaginary and the roots of the quadratic are complex.

7. $k = +\infty$. This requires that c be positive and $b = 0$. From (A) it appears that the roots are then purely imaginary with opposite signs.

8. $k = 0/0$. If k is indeterminate in form, both b and c must be 0. (A) shows that in this case both roots are equal to zero.

The foregoing results may be exhibited graphically as follows:

$k = -\infty$	$k = 0$	$k = 1$	$k = +\infty$
roots real equal opp. signs $x_1 = +Q$ $x_2 = -Q$	one root zero $x_1 = 0$ $x_2 = -2b/a$	roots equal $x_1 = -b/a$ $x_2 = -b/a$	roots imaginary conjugate $x_1 = +iQ$ $x_2 = -iQ$

$-\infty < k < 0$	$0 < k < 1$	$1 < k < +\infty$	$k = 0/0$
roots real unequal opp. signs $x_1 = P+Q$ $x_2 = P-Q$ $\lvert P\rvert < \lvert Q\rvert$	roots real unequal like signs $x_1 = P+Q$ $x_2 = P-Q$ $\lvert P\rvert > \lvert Q\rvert$	roots complex conjugate $x_1 = P+iQ$ $x_2 = P-iQ$	roots equal zero $x_1 = 0$ $x_2 = 0$

PRODUCTION OF ALUMINUM IN 1919.

The value of the primary aluminum produced in the United States in 1919, according to reports received by the United States Geological Survey, Department of the Interior, was $38,558,000 as compared with $41,159,000 in 1918. This decrease of $2,601,000 was probably due to a curtailment of production in 1919, forced by the accumualtion of large stocks of aluminum by both the government and the manufacturers in 1918. The market prices quoted during the first four months of the year were lower than those which prevailed during the remaining months, and apparently most if not all of the stocks were taken by the beginning of the last quarter.

PLUS AND MINUS SIGNS IN ALGEBRA.

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The beginner in algebra is always confronted with the necessity of learning the double significance of the + and − signs. They are signs of the operations of addition and subtraction, and also signs of quality, positive and negative. In the language of grammar they are both verbs and adjectives. In reconciling these two views, we either must make elaborate explanations, or else attempt to dodge the trouble by omitting any reference to it. The present paper explains a mode of treatment of this difficulty.

After the pupil has been shown the existence in nature of both positive and negative numbers, the signs + and − being used as signs of quality or adjectives, we consider the question of addition. In adding a column of three or more numbers the teacher calls attention to the fact that the list of numbers may as well be written in a line instead of in a column, the numbers being separated by commas, as $+17$, -6, -13, $+5$, -18, just as we find similar problems stated in arithmetic. However, inasmuch as the signs separate the numbers so that 17 and 6 cannot be interpreted as 176, the commas may be omitted. This omission was impossible in arithmetic unless we in some way spaced the numbers. In other words, algebra needs no sign for addition. *Addition is to be understood as long as no other operation is indicated.* When handling polynomials also we may eliminate the need of a sign for addition by adopting a new attitude toward parentheses.

Consider the expression $3(2a-5)$. Instead of saying that the parenthesis is a symbol for grouping of terms, we say that the presence of a parenthesis should always suggest multiplication, i. e., a quantity in a parenthesis should always be multiplied by the quantity preceding it. Hence $-3b(2a-5b)$ is a problem in multiplication, the multiplier being $-3b$. And $3a(5a-3b)-3b(2a-5b)$ is a problem in two multiplications, followed by the problem of addition. The pupil should not think of this as a problem in multiplication followed by a substraction, for the −sign is an adjective qualifying $3b$ and is not a verb. The addition follows the multiplication because no other operation is indicated.

When a quantity like $-3(2x-y)+(-3x+2y)$ is met, I explain to the class that if no multiplier is present before the paren-

thesis, the number 1 is understood and the problem means $-3(2x-y)$, $+1(-3x+2y)$. This is consistent with previous experience for we write a letter x when we mean $1x$, and write $-x$ meaning $-1x$. Thus $4(2x-3y)-(6x-y)$ means that $6x-y$ is to be multiplied by -1 and added to the result of the other multiplication.

Let us see what changes in the order of the exercises this new attitude toward a parenthesis will involve. Regarding the parenthesis in the old way as a symbol for grouping, the pupil first learns to remove parenthesis from such an expression as $(3x-y)-(6x-8y)$ and is later taught that $3(x-2y)-2(x+6y)$ means $2x+12y$ is to be subtracted from $3x-6y$, and the teacher must avoid single expressions like $-6(2x-3y)$ because the pupil will want to know from what he is to subtract the $12x-18y$. Note how many different explanations are necessary. But using the new definition of a parenthesis, all these problems are of one kind, problems in multiplication. The teacher should reverse the order illustrated and consider first, quantities like $-6(2x-3y)$; second, $-6(2x-3y)\pm2(x-7y)$ as this uses addition after the multiplications; third, quantities like $(3x-2y)\pm(6x+8y)$ where the invisible number 1 is understood.

Having eliminated the $+$ sign for addition, the $-$ sign for subtraction can also be dispensed with. We begin as usual by explaining that subtraction in algebra does not mean what is left after something is taken away, but involves finding what must be added to the subtrahend to obtain the minuend. The writer has always found that this can be done easiest by using equations, a subject which is usually begun fairly early in the course, and should be available when subtraction is reached. Thus, let $x=$ what must be added to -6 to obtain 10. Arrange several problems on the blackboard in such a scheme as:

Subtrahend	-6	$+5$	-7
Minuend	$+10$	-3	-2
	$-6+x=10$	$5+x=-3$	$-7+x=-2$
	$+6 \quad =+6$	$-5 \quad =-5$	$+7 \quad =+7$
	$x=16$	$x=-8$	$x=\ \ 5$

Then ask: "What was added to each member of the equation? What was added to the minuend in each problem?" This analysis is easier to understand than why the loss of a debt is the same as the gain of an asset, etc. The pupil sees that subtraction involves two steps, the multiplication by -1 followed by an addition. Hence no sign for subtraction is ever necessary.

Wishing to subtract $6x-7$ from $3x-9$ we write $3x-9-(6x-7)$ meaning $3x-9, -1(6x-7)$ the comma and the one being omitted according to custom.

Thus the verbs + and − are eliminated from our grammar; only the adjectives + and − remain.

The usefulness of this attitude toward the + and − signs and parentheses can be seen in simplifying such an expression as $3(a-2b)(4a-5b)-5(2a-b)(a+4b)$. This would be done as follows: it equals

$$\begin{aligned} &3(4a^2-13ab+10b^2),\ -5(2a^2+7ab-4b^2) \\ &= 12a^2-39ab+30b^2-10a^2-35ab+20b^2 \\ &= -2a^2-74ab+50b^2. \end{aligned}$$

Again in later work, the pupil would be taught that the equation $(3x-7)/6 - (2x+6)/3 + 2(x-6)/5 = 0$ should be regarded as ${}^1/_6(3x-7),\ -{}^1/_3(2x+6),\ +{}^2/_5(x-6) = 0$ and then as $5(3x-7)-10(2x+6)+12(x-6)=0$.

THE DISMAL SWAMP OF VIRGINIA AND NORTH CAROLINA.

Few regions in America are more adorned by nature or more interesting to the tourist and scientist than the Dismal Swamp of Virginia and North Carolina. Though the entire region, may present a dismal appearance in winter and some parts of it in all seasons, the swamp is annually visited by many pleasure seekers and has long been a place of study and absorbing interest to the geologist, the botanist, and the zoologist. It lies in the Coastal Plain of Southeastern Virginia and Northeastern North Carolina. Most of the surface consists of recently formed peat, the residuum resulting from the arrested decomposition of vegetation, but the underlying rocks are older and record events that occured thoussands of years ago, in the pleistocene epoch. The peat ranges in depth from one to twenty feet. Contrary to popular belief this peat has antiseptic and preservative properites, and consequen ly much of the surface water is pure. Though no remains of primitive man or of extinct animals like those uncovered in the bogs of Ireland have been found in the Dismal Swamp, the peat contains many well-preserved trunks of cypress trees that lived long before America was settled by our ancestors.

The region may be readily reached from Norfolk by canals, whose banks, shaded by stately trees and graceful vines, afford an ever-changing scene from the deck of the little steamer that daily plies their waters. When the swamp was young it was entirely covered by water, but much of the water has drained off through these canals, and large areas are now dry. In the center is a picturesque body of water called Lake Drummond, the origin of which is a mooted question. According to the most plausible hypothesis that has been advanced, it is the remnant of a large body of deep water which once covered the entire region. The water in this lake, because of its remarkable keeping property, was used in earlier years for drinking on trans-Atlantic voyages. It is amber-colored and is known locally as "juniper water." As the name implies, the peculiar color has been ascribed to the bark of the white cedar (juniper), which abounds in the swamp. It seems more likely however, that this color is given to the water by its finely divided vegetal content or by the dye extracted from the brown peat.—*U. S. Geol. Survey.*

THE CLAIMS OF MATHEMATICS AS A FACTOR IN EDUCATION.[1]

By Professor C. N. Moore,

The University of Cincinnati.

It is perhaps needless to state before this audience that the subject assigned to me is a large one, and that it would require several volumes to treat it in detail. In order to confine myself to the limitations of a brief address, it becomes necessary then to make certain restrictions as to the scope of the discussion not suggested in the title. In the first place I shall confine myself to the field of general education as distinguished from the fields of special education, such as vocational, professional or technical education. And in this particular field, by no means a narrow one, I shall consider only certain broad aspects of the question.

Before deciding on what is important in general education, it is necessary to define with some precision the proper aims of such education. In the absence of any general agreement on this question, I offer the following definitions as expressing my own ideas on the subject. It should be understood that in these statements I am restricting myself to the education of the mind, thus expressly excluding physical or moral education.

First of all, general education should lead to a thorough acquaintance with certain facts and ideas of central importance, about which the existing body of human knowledge is grouped. It should further develop the ability to use these ideas and facts in their own and related fields. In the second place, such education should furnish a well-rounded mental discipline, obtained by properly proportioned efforts in each of the various fields of mental activity. Lastly, it should give to the student a certain intellectual culture, which may be defined as the appreciation, in a broad sense, of the most important elements in the general scheme of modern civilization.

This is an ambitious program of course, and it is too much to expect that it can be fully completed in each individual case, but it seems to me to be the proper ideal toward which we should strive, and I believe it is at present realized in a large measure by the best of our students in the best of our schools. At any rate, if education is to be improved, we need to set our standards higher than the average level of current practice. So I feel no hesitancy in basing my discussion of the importance of mathe-

[1]An address delivered before the National Council of Mathematics Teachers at the meeting of the National Education Association in Cleveland, Ohio, Feb. 24, 1920.

matics in general education upon the above statement of the proper aims of such education.

Among the ideas and facts of central importance, in our modern civilization, we must obviously list the properties of number and space. Precise ideas about almost anything in the universe involve to some extent these properties, and the bulk of our scientific and technical knowledge involves them to a considerable extent. It is no accident that mathematics was the earliest of the sciences to develop. The human race could make no progress in other fundamental sciences, such as astronomy and physics, until it had investigated the elementary relations of number and space. It could not properly attend to many other matters of a more immediate practical application, such as the measurement of time, the division of land, the erection of buildings, the conduct of commercial transactions, without the results of certain mathematical investigations.

Although the science of mathematics appears to have originated under the urge of practical necessity, it was not long before mankind developed a keen interest in the development of mathematics for its own sake. The conceptions of number and space as used in mathematics are creations of the human intellect, abstractions from our sensory experiences which transcend the limitations of the senses. Hence, in working with these conceptions we reach a precision of results unattainable in other fields of investigation and which has furnished a peculiar satisfaction to some of the world's greatest intellects. It is fortunate for the progress of civilization that this is the case. Some of the most important discoveries in other fields would never have been made, or else would have been long postponed if certain mathematical theories had not been previously studied for their own sake. For example, Greek mathematicians studied the properties of the conic sections because these properties constituted a beautiful and harmonious theory in the field of pure mathematics, which aroused their highest admiration and interest. Centuries later, the mathematical astronomer, Kepler, was able to discover the laws of planetary motion because he knew about the properties of conic sections. The discovery of the calculus by Newton and Leibnitz was the culmination of a long series of advances by themselves and their predecessors in the field of pure mathematics. Because of this discovery, Newton was able to verify his hypothesis with regard to gravitation and thus establish one of the most fundamental laws, with regard to the

universe in which we live, that has yet been discovered. The invention of wireless telegraphy may be traced back in a direct line to certain investigations in mathematical physics made by Clerk Maxwell. These are only a few illustrations of the important role that mathematics has played in human progress.

The very brief account I have given of the contributions of mathematics to the development of our modern civilization is sufficient to show that some understanding of mathematics is necessary for even a superficial acquaintance with the nature of that civilization, and it goes without saying that this knowledge should include more than the technique of arithmetic. For practically none of the applications of mathematics in science, in technology, and in certain commercial fields, can be understood by one whose knowledge is limited to arithmetic.

I think it ought to be clear, then, that the elements of algebra and geometry must be classed among those central ideas which should certainly be included in general education. Furthermore, they should be placed as early in general education as the maturity of the student will permit, on account of their usefulness in other fields of knowledge, such as the natural sciences. The more elementary notions of trigonometry and analytical geometry ought to be included in the mathematics for general education in place of some of the topics now taught in algebra and geometry. I would make this substitution on the basis of my formulation of the aims of general education. For the trigonometric functions and graphs are ideas of more central importance than the finesse of algebraic technique and the proof of one intuitive fact in geometry by means of other intuitive facts.

I have now justified the inclusion of mathematics in general education from the standpoint of the first of the three aims of general education that I have formulated. Let us consider the second aim, namely, the securing of a well-rounded mental discipline. I know there are certain professional educators who see red when the terms "mental discipline" or "general training" are mentioned, but practical men of affairs and people in general who are doing the important work of the world agree that a proper system of general education contributes something to the development of the individual which we must needs call by some such name. In this connection the following brief quotation from Admiral Sims' interesting story of "The Victory at Sea," is particularly pertinent: "I have even been inclined

to suggest that it would be well, in the training of naval officers in the future, to combine a college education with a shorter intensive technical course at the Naval Academy. For these college men have what technical academies do not usually succeed in giving, a general education and a general training, which develops the power of initiative, independent thought, an ability to grasp quickly intricate situations, and to master in a short time almost any practical problem. At least this proved to be the case with our subchaser forces." As the use of an education in the conduct of important practical affairs ought to be a better test of its value than experiments on the crossing out of letters on a page, or the guessing of weights and magnitudes, I should not hesitate to use the term mental discipline until some one suggests a better one to express such concrete results of a good general education as have been noticed by Admiral Sims and other observant men who are engaged in directing important and difficult tasks.

We are to consider, then, whether or not mathematical training is essential in securing a well-rounded mental discipline. Since we have already pointed out that properties of number and space are of such fundamental importance in almost all phases of civilization, it ought to be evident that a well-rounded mental discipline cannot be secured without a considerable amount of study of such properties. This is entirely aside from the value of mathematics as a training in logical thinking, the discussion of which would carry this paper beyond proper bounds.

We come finally to the third aim of general education, namely, the securing of a certain intellectual culture. In this connection I do not hesitate to assert that no one can have even a cultural appreciation of the nature of this highly technical and scientific age in which we live without some knowledge of mathematics. If the time permitted, many facts might be adduced in support of this statement. As it is I shall limit myself to a very few interesting and pertinent ones that were pointed out several years ago by Professor S. G. Barton of Flower Observatory. Professor Barton enumerated the titles of 104 articles in the eleventh edition of the *Encyclopaedia Britannica,* in the course of which the symbols of the calculus were used, Only about a fourth of the headings are those of pure mathematics, and the list contains such titles as bearings, bridges, clock, gravitation, heat, lens, lubrication, map, molecule, power transmission, shipbuilding, sky, steam engine, strength of materials, sun, tide, and measure-

ment of time. If the elementary notions of algebra and geometry had been made the basis of selection instead of the use of the symbols of the calculus, the length and scope of the list would have been vastly increased. Does anyone need any better objective proof of the necessity of the study of elementary mathematics, in order to arrive at a cultural appreciation of present day knowledge?

TALC AND SOAPSTONE INDUSTRY.

United States is Largest Producer.

America leads the world in talc and soapstone industry, not only in production but especially in manufacture and use. The output of talc in the United States sold in 1918, according to J. S. Diller, of the United States Geological Survey, Department of the Interior, was 191,477 short tons, having an average value of $10.91 a ton. This was a decrease of about 7,000 tons in production as compared with that of 1917 but an increase of more than $200,000 in value.

Talc was not considered a war mineral and its production was retarded by the war, but the spread of knowledge concerning its uses and its usefulness has stimulated the talc industry. Its more general use has been promoted by the formation of a talc and soapstone producers' association of which Freeland Jewitt, of Boston, is president.

Vermont produces the largest quantity of talc, but the output of new York is of greater value. California ranks third in quantity and value and, notwithstanding the general decline in production elsewhere in the United States in 1918, it more than doubled its output of 1917. California produces some soapstone, but the bulk of its production is ground talc, mined in Inyo and San Bernardino counties, where it is more or less intimately associated with limestone and in part possesses a fibrous structure similiar to that in much of the talc of the Gouverneur region, New York.

The United States produced about 58 per cent of the world's output of talc in 1918 and in addition imported more than 11 per cent of all the talc produced by the rest of the world. As little if any talc was exported, it is evident that the United States is preeminently a consumer of talc. Canada is the only competitor for the domestic trade in middle-grade talc. About 12,000 tons, 96 per cent of the talc imported in 1918, came into the United States from Canada.

The United States is well supplied with low and middle grade talc but lacks high-grade material for use in toilet powder, electric insulators, and gas burners, commonly called lava tips. The talc used for such purposes is imported mainly from Italy and France and, through other countries, from India.

Within the last two years a new and interesting source of talc has been found in a large dike of surpentine in Harford County, Md.

Virginia is the only great producer of soapstone in the world, shipping more than 15,000 tons in 1918. The production has, however, declined irregularly for the last ten years. Soapstone is one of the rocks that are most widely useful to primitive peoples, who on account of its softness, resistance to sudden changes of temperature, and slow radiation of heat, employ it chiefly as "potstone"—that is, for making pots. We make a similiar use of it in soapstone stoves, foot warmers, and disks for fireless cookers, although in this country it is used principally in laundry tubs, laboratory tables, hoods, and sinks.— *U. S. Geological Survey.*

SOME APPLICATIONS OF THE PROJECT METHOD IN HIGH SCHOOL MATHEMATICS.

By Edith St. John Eaton,

Berkeley, Calif.

If one judged the perfection in the teaching of a subject by the length of time in which it has been studied, then perfection in mathematics might be expected, after having been taught for centuries. The real fact is that only very recently have teachers varied to any marked degree from the old Greek geometer, Euclid. Mathematical thinking did not originate with mathematicians nor was it recorded by mathematicians but it originated with philosophers, and these men thought in general terms. If one will look over the list of Greek mathematicians he cannot but be impressed by the fact that they are also the men who ranked high among the list of philosophers. What was true in earlier times is just as true in the seventeenth century. D'Alembert Descartes, and Leibniz are equally great in philosophy as in mathematics. The difficulty for us arises when we realize that these philosophers put down their conclusions in logical order often far from the order in which they reached these conclusions. As a result we have many generalizations. We, so far, have proceeded on the theory that once a pupil gets these generalizations, he will be able to use them. We have found however that a very high average of students are themselves unable to see the application of the generalization or often cannot apply it when it is pointed out to them. In this very fragmentary way, I have endeavored to answer the question, "Why is it necessary for us to find a new method in mathematical teaching?" In this paper I hope to examine the project method as one solution.

What is a project? "The project is a motivated problem, and, as such its solution requires thought, its completion results in the production of something of value to the student. It is always concrete, since children's sense of values comes largely from commercial sources; it follows that a school project is judged by business standards, the appropriate method of solution is that of commerce, the tools and the materials used in the solution should be adapted to commercial production; the project is a small sample of real life brought to school; it is adapted to the development of traits required for a successful vocational career." The quotation is from J. A. Randall of Pratt Institute and might imply perhaps that the project method is especially useful in mathematics. It may be, but if so, the literature on the sub-

ject is yet to be written. The reference desk of one of our largest universities reported that they did not find one book, article, or pamphlet written on the subject. The material presented is not a compilation of other people's projects, but a statement of a few ways that I can see its application in high school mathematics.

Certain University schools have worked out projects in arithmetic for their Junior high schools. I have in part tried this myself; such as a class in mensuration building a house. From the time the lot is purchased, through the stages of drawing the ground plan, excavating, removing the dirt, mixing the cement, laying the joists, building the walls and even to the hanging of the stenciled curtains in the individual's bedroom, each child proceeds. With one class it is an individual project; and, in another, it is a group project, according to the desire of the teacher. In the former case, every child works out the amounts of materials and costs for his individual "house beautiful"; in the latter, some opportunity is given for choice of work, although eventually every child has had experience with the various steps involved in the project.

In Monroe's *Cyclopedia of Education*, I found this statement, "Efforts to find commercial or scientific applications of topics like factoring, quadratics, or radicals have not been very successful; the immediate interest in these subjects must be found in the mathematics involved, in the game element, in the assurance that the work is necessary preparation for both pure and applied mathematics." I agree with the author in those particular phases of the algebra. However, there is one project which is quite commonly used in algebra. No argument is necessary to convince people today that the graph is a part of every general culture course. One can scarcely pick up a daily paper or magazine in which there is not a graphical representation of some data. One must have graphs to master physics successfully, chemistry, mechanics, economics, or meteorology.

There are only two project graphs which I endeavor to develop, from material already worked out; health, trade, or census reports, geography, interest tables, and secondly, from material which the pupils themselves collect, such as the fluctuation on the market of any commodity (one graph handed in was on the prices of eggs for the current year) others, weather reports taken hourly, deaths from influenza in comparison to other infectious diseases. The construction of practical graphs is an individual project.

J. W. A. Young in his text on the teaching of mathematics gives an illustration of what I consider could be used as a group project. If the daily profits of one or two factories are three dollars per workman less a fixed operating charge of eight dollars per day and the second factory makes five dollars per day but its fixed operating charge is twenty-four dollars per day, represent the net profits of each factory according to the number of workmen. For what number of workmen will the first factory make the larger profit? The second? For what number of workmen will they make the same? What is this profit? Very slow development and considerable thinking is required to have each individual grasp clearly the idea of an equation in two unknowns, each variable, and the "graph as recording a restriction to which these variables are always subject in their variation, and that the curve is the representation of their variation under this restriction."

My projects in plane geometry consist first in endeavoring to use motion or any other aids which will help to convince the adolescent mind that what is asserted is fundamentally true. A group project consisted in using yardsticks upon the floor to form a convex polygon. By carefully placing the rulers so that the exterior angles were produced in succession, one student was told to walk through the exterior angle at that corner and also for each successive corner. Eventually he reached the starting point and realized that he had made a complete turn or had passed through the angular space about a point. In the case in question practically every member of the class also came to the same conclusion.

The following individual project in plane geometry was tried: At the conclusion of the work on parallelograms in the beginning course and of circles in the second half of the work, I asked them to reproduce a design in which the decorator or the architect used an application of his knowledge of that part of the material we had just completed, to produce a decorative or working design. Filing cabinets, friezes, designs for wall paper, oilcloth, linoleum and patterns from Italian pottery were executed with real care. One girl drew the home library in perspective which illustrated all the figures so far studied.

Later projects were the measurement of the height of the school building and of the flag pole, the distance between two points which were themselves accessible but which were separated by some objects which prevents direct measurement by a line

connecting them. Plane geometry is a series of projects—hardly a lesson but what there is presented a problem whose solution requires carefully built proof in order to establish the truth of a given statement. Professor Kilpatrick, of Columbia, in his article on the project method would include originals in geometry under his third class, "Where the purpose is to straighten out some intellectual difficulty."

My object in using projects outside the regularly assigned task is not to divert the pupil from the main reason for studying geometry, ability to do real reasoning, but only to round out his school experience by a glimpse into extra-school experience and show him more clearly the need for pure mathematics.

In solid geometry, I have used individual projects only. I will give three illustrations; two were models which would prove to each individual the truth of such a statement as: "Through a given external point, there can be drawn one line perpendicular to a given plane and only one." And also the theorem, "The volume of any parallelopiped is equal to the product of the base by its altitude." The third was to determine which are the five regular polyhedra and why it is impossible for there to be more than five. The models were made individually and brought to class. Comparison with the other models brought about a quick recognition that there had been a failure to comply with the conditions imposed.

In trigonometry, one has more nearly ideal conditions for the application of the project method than in any other high school mathematics. The tools being acquired, there are real live projects which pupils can solve—the length of an unbored tunnel, the height of an aeroplane if observed from two points on the ground and in the same vertical plane with it.

Whenever the project method is used, its value is determined by the value to the student himself, secondly, by its usefulness to the other members of the class as a record of useful information, and as a third value, the skill obtained by the project will be, not only of present worth but of ultimate value in solving other projects.

De Garmo in his *Principles of Education* says, "the need for a laboratory for mathematics is as crying as a laboratory for science. In the latter it is a crying necessity. The literature economics, and history classes have the library as their form of laboratory. The mathematics workroom is a formal recitation room." I can partially agree with this statement but it seems to

me that we can bring the outer life into touch with the inner life of the school through some definitely arranged projects.

The project method developed in a laboratory is one leading from the concrete to the abstract, it emphasizes the doing, it requires a student to accomplish something within his capacity, and brings the applications of mathematics into prominence and does help him to clarify his notion of space concepts. But, in view of all this, I cannot but feel that it has several detrimental features. It is not easy nor is it always wise to make students discover all mathematical facts by experiments. Life is made up of occasions where we cannot reach our conclusions through our senses. Such work is liable to degenerate into a form of hand work, not head work; it is based on a wrong assumption that pupils cannot comprehend and thoroughly enjoy demonstrational mathematics. Projects give very little training in true mathematical thinking; the student gets mathematical facts but not mathematical reasons.

The project method can be a valuable supplement to the teaching of mathematics but it requires skill if its results are commensurate with the time involved. Original thinking is what I hope to generate by my mathematical teaching, and projects advisedly used can and do contribute to that end. We want power, not knowledge, in mathematics and must justify the applications of any method by firmly believing that it fulfills one of the ideals of mathematical teaching.

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ARSENIC IN 1919.

The domestic production of arsenic in 1919, according to estimates compiled by James M. Hill, of the United States Geological Survey, Department of the Interior, was 5,900 short tons, as compared with 6,400 short tons in 1918.

The imports of arsenic for the first nine months of 1919, as reported by the Bureau of Foreign and Domestic Commerce, Department of Commerce were 1,389 short tons. The imports for the year will probably amount to about 1,550 short tons. Most of the imported arsenic came from Canada and Mexico, though some came from Belgium and Japan.

The quantity of arsenic available for consumption in 1919 was about 7,450 short tons, as compared with 7,170 short tons in 1918. There were no exports either of foreign or domestic arsenic during the first nine months of 1919.

Two domestic companies who produced considerable arsenic in 1918 reported to the Geological Survey that they produced none in 1919 on account of low prices.—*U. S. Geological Survey.*

AIR CONDITIONING IN SCHOOL BUILDINGS.[1]

By S. R. Lewis,

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Revolutionary discoveries of basic importance are extremely rare. The art of ventilation has received much study by rather competent people during at least fifty years, and there has developed a general practice covering fundamental principles which I am very sure should not be lost sight of. There are, these days, many opportunities to take up new schemes, but the old principles must not be violated if we are to hope for any improvement.

The lungs may be considered as mere bags, lined with a material well designed to prevent any infection. In fact, authorities say that air cannot carry from the lungs of one person to another person in ordinary human contact any harmful thing, infection being almost entirely by mouth or broken skin. The lungs have a very small air capacity compared with the amount of fresh air we have been accustomed to furnishing; they are worked to capacity only a very small part of the time; the passages and tubes leading to them always hold their contents of air which must be rebreathed at each inspiration, so that the fresh air actually taken in and discharged each minute amounts to not more than .25 of a cubic foot.

We do not know what the poisonous or harmful quality of expired air may be, if there is anything harmful in it. It is clear, however, that whatever it may be is not recognizable by any of our senses, and that whatever objectionable thing there may be in the air, of which our senses acquaint us, could hardly have been put there by contact with anyone's lungs. Further, the condition of the air inspired, aside from its temperature, is of little moment, so long as it does not carry infected dust or drops of water (which may possibly cause trouble).

The temperature of the air seems to be important as Nature, by the inexorable provision for mixing the fresh air with the already warmed air in the passages, insures that it shall not be too cold. Anyone who enters a refrigerated space in warm weather experiences the feeling that he can breathe more easily, that perhaps less air is required, though there may be no chemical difference.

[1]Read before the General Science Section, Central Association of Science and Mathematics Teachers, at Lake View High School November 28, 1919.

The skin is an admirable servant. It prevents the entry of infection unless broken. It is impervious to all chemical conditions of the air encountered in ordinary life. The temperature at the skin, however, is of vital importance to the party inside the skin. Nature has given us an elaborate mechanism for controlling this temperature, which depends for its functioning on the presence of moisture in the air and on movement of the air.

As far as we know, therefore, within the ranges of air as ordinarily encountered in life, neither as to lungs or skin, does it very much matter what chemical condition the air is in, and ventilation or air conditioning as far as it applies to schoolhouses means regulation of body temperature. As long as the air around the bodies of the pupils remains within reasonable limits of the optimum condition, the body functions will achieve the optimum without undue stress, leaving the mind free for highest educational efficiency. When the air gets too hot or too cold in its effect upon the skin, however, the body will originate a complaint; the pupil will become restless or sleepy, if not liable to weakening or infection.

It is not necessary, in order to experience the unpleasant effects of crowding or overheating, to be indoors. Similar conditions are often found in assemblages of people out of doors when there is no wind or where the topographical situation causes stagnant pockets. We seem to be most comfortable out of doors when in a gentle breeze, at a temperature slightly cooler than that of the body.

I believe that a schoolroom should have an arrangement of air supply which will rub over the bodies of the pupils in an appreciable current at such a temperature as not to cause discomfort. This temperature will depend on moisture and speed of movement, bearing a ratio to the room temperature. The temperature of the entering or moving air cannot safely be fixed, for entering air much cooler than the average room temperature inevitably causes discomfort. No great fear need be apprehended that the entering air may be too warm because in an occupied class-room the problem is nearly always one of cooling rather than heating. The floor must be warm enough to prevent cold feet. There is some evidence that when the feet are kept warm the balance of the body will endure a remarkably low temperature.

It is highly desirable to eliminate the local circulation or

short air circuits caused by hot radiators, cold glass and wall surface, and by cold air leakage in through walls and windows. If schoolrooms had double walls impervious to air, and double windows, not only would the heating problem be simplified and the cost much reduced, but also the ventilation would be much improved.

Where the air can be moved positively over the bodies of the people in a uniform current, the heating and ventilation are nearly always reported excellent. Such systems are possible at present in interior rooms having low ceilings, where inlets can be at one end, with outlets at the other end, giving a slow moving cross-draft, or in auditoriums where inlets can be under the fixed seats, with outlets at the ceiling giving a slow moving up-draft. If rooms are thoroughly heated prior to occupancy, and delicate temperature control is maintained and the volume is so great that the entering air need not be more than about ten degrees cooler than the warmest part of the room, downward ventilation is practicable.

One of the existing and much used systems of school ventilation introduces the fresh air, heated to an extent sufficient to overcome the chilling effect of glass and walls, say, around ninety degrees when it is zero outside. Another introduces it at about seventy degrees and compensates for chilling effect by direct radiators placed in the rooms.

Owing to physical limitations due to the exigencies of construction, with the first system the air cannot ever be introduced cooler than about sixty-five degrees, and with the second system the air goes everywhere at the same temperature, whether to a room crowded or empty, sunny or dark. The sixty-five degree limit of the first system is necessary to prevent drafts when the room temperature runs up due to the heat from the occupants or from sunshine. With the second system, overheating from the same sources, which are difficult to control, becomes even more common.

Both of these systems introduce the air horizontally overhead, and exhaust it at the floor. Of necessity, with both, chaotic conditions exist in rooms as to diffusion of the fresh air. All warm things, lights, radiators, bodies of occupants, sun-heated furniture, create upward currents of air whether fresh or stale, like miniature fountains. All cool things, such as windows and outer walls, cause downward currents. Some of these little circuits seldom change their content. Some stagnant

spots exist. An outsider may detect these spots by sense of smell on entering any schoolroom. When an occupant of such a room, who has been there some time, complains of closeness or oppressiveness, we can be sure that while it may be odorous he cannot detect the odor. What he feels is temperature, and nothing else. Lack of moisture or excess of moisture will evidence itself to him by sense impression of temperature. Increase of carbon dioxide may cause more rapid respiration, but even this will usually be indicated by a feeling of increase in temperature. If there is, however, an appreciable movement in the air within the room, so that he is swept over by a breeze, a very high temperature and a very rank odor will seem to the long-time occupant the finest of conditions.

There are many fads, fancies and fallacies about school ventilation, among them the one that by open windows the millennium may be attained. I have made careful tests over several weeks of a number of schools in which open window ventilation was being conscientiously operated. It was impossible to provide enough fresh air to control the temperature without creating objectionable drafts. The teachers could not be depended upon constantly to remember the windows, with the result that the rooms were many of them uncomfortably hot, then uncomfortably cold. The windward rooms received fresh air when the windows were opened, but the leeward rooms acted as vent flues for the windward rooms and received no fresh air at all. Every heated building has a neutral zone, above which pressure is outward; below which pressure is inward. The rooms below this zone received fresh air; those above it were vent flues for the lower rooms, and could not be kept cool. The direct inflow of dust was objectionable, and in every storm all intake windows had to be closed. Street noises were troublesome.

The unit system, whereby every room has a separate fan and heater, is entering into prominence though subject to nearly all of the objections of window ventilation, and being as yet even more crude than the older centralized types as to temperature regulation. The unit system is presumably adjustable by the teacher to compensate for varying wind conditions. The teacher will not and cannot pay much attention to outside wind conditions. No unit systems have yet been found which do not carry the same objections as the other systems, and they add some new complications of an electrical, mechanical and operating nature. They discharge the fresh air toward the ceiling

in front of the window, and exhaust it at the floor at an interior wall. One fad having some vogue entails an air washer, sealed windows, and recirculation of the air. No better distribution or temperature regulation is attempted. The air washer, when operated, will remove much dust, and some odors. It may promote some bacteria, though in all probability these will not hurt anybody. It is possible to operate such plants as this without running the air washers, however, and under such conditions, the plants become highly odorous as to their product, and temperature regulation becomes difficult.

It has been found most difficult to compel operating engineers to keep the air washers in clean condition, or to insure their continuous operation, since the building can be heated without operating the washers, saving power, fuel and labor. When there is little or no cooling surface in a room, such as single glass or exposed wall, the local heating surfaces, as radiators, may be omitted, and the air may be delivered with impunity directly across the rooms over the bodies of the occupants. The ventilation of such fortunate rooms is invariably unnoticed, or if noticed at all is called excellent, provided that the temperature control is good. Where fixed seats are available upward ventilation may be used, suiting the temperature of the entering air exactly to that of the occupants, and disregarding the losses of walls or glass. This also depends for its excellence on the efficiency of the temperature control, and requires considerably more elaboration of the control than is common in practice.

The last two types depend, it will be noticed, upon displacement, as compared with the other schemes, which operate by dilution.

I am willing to admit that ventilation by dilution is not ventilation at all. I believe that ventilation can be achieved only by displacement.

Temperature regulating devices have reached the stage where almost any desired refinement can be obtained, and we know how to build schools with hollow walls and double glass; and know that the fuel saving alone will pay the interest and sinking fund on the investment, to say nothing of the improved living conditions obtained. It should be possible with every scheme of ventilation, to open the windows whenever desired, to get the breezes in warm weather, or to stimulate the pupils with a cold snap for a few minutes occasionally in winter.

Psychologically, the first invitation for complaint about a

ventilating system comes from the mistaken instructions given by some ventilating engineers to the end that windows shall not be opened. In a properly constructed building we could introduce the fresh air at a temperature very close to that desired in the rooms, in a gentle breeze sweeping the room like a stream of water from a hose, even introducing it at the floor at one end of the room, removing it at the ceiling at the other end, perhaps introducing it at a tangent to the periphery of the room and removing it at the center, like a cyclone dust separator, causing a whirling breeze which should move all the air in the room all of the time.

All of these things have been done in schoolrooms, and successfully, on an experimental scale. These methods are common practice for theatres. In artificially cooled rooms air introduction is at the floor and removal is at the ceiling. Ventilation, which is simply removing excess heat, becomes rather simple when laws governing heat are followed. Do not hesitate to open the windows when it gets too warm. Excess temperature is a confession of weakness on the part of the design or operation of the plant in your building. The school is for the benefit of its occupants and overheating is harmful at other places than the coal pile.

Mechanical ventilation is indispensable. We cannot in any other way insure positive air movement. Local electric fans, to insure positive movement and breeze effect in existing rooms having an old fashioned air supply, will be found to be of great advantage. In new buildings the following are some of the features upon which advanced engineers are well agreed:

1. Mechanical ventilation, using plenum systems, that is with a supply fan pushing the air in. Exhaust fans for all toilet rooms, all interior rooms not having windows, all cooking rooms, all chemical laboratories, and other local sources of heat or objectionable fumes. Exhaust mechanical systems without supply fans have not been found efficient or satisfactory except possibly when a well designed fan arrangement having a separate fan for each room, combined with adequate temperature control and dust removal, is installed.

2. Heating arrangements such as will keep all plumbing apparatus and plants from injury by low temperature without running any fans.

3. Separate heating and ventilating units for each auditorium, gymnasium or other special room likely to be used at separate times.

4. Electrical operation of exhaust fans for toilets, special and interior rooms so that they may be ventilated in the warm weather of spring and fall when no heating is required.

5. All horizontal supply ducts are to be of sufficient size to permit access for cleaning, in general not less than 6 ft. high or 2 ft. wide, provided with electric lights, ample doors for access, and provisions for washing out with water or for vacuum cleaning.

6. If direct radiators are used in classrooms, they are to be so disposed or shielded as to prevent radiant heat from them striking the occupants.

7. All outside walls of the building are to be furred, with air space, and are to be of the warmest possible construction, preferably having a waterproof air-tight coating inside the brickwork. All windows are to be double, and weather-stripped. All outside doors are to have vestibules. There shall be a hollow attic space.

GENERAL SCIENCE AND VOCATIONAL EDUCATION.[1]

By Prof. A. W. Nolan,

State Supervisor of Agricultural Education, Springfield, Ill.

First, last, and always we must consider vocational education as directly training for useful employment upon a productive basis. The Vocational Education Act is right in limiting its aim, so that the "controlling purpose of such education shall be to fit for useful employment." The advocates of vocational education have no quarrel with the friends of non-vocational education, nor should the latter criticize vocational education because it does not include in its aim the broad values of a liberal education. Each has its part to play in the educational program, each has plenty to do to look to its own field, and society needs the services which each can give.

It may not be clear to us all, as to which field general science belongs in our harmonizing of vocational and non-vocational education. To me it bears a vital relationship to both, and it is to this relationship I wish to direct this discussion.

In all vocational work, where manipulative or mental processes are required to carry on the vocation, there are three phases of instruction to use in following out a curriculum,

[1]Read before the section on General Science, Nov. 29, 1919.

They may be called the "three r's" of vocational education. rules, reasons, and related studies. In the consideration of any manipulative process of any of the vocations included under the Smith-Hughes Act, there are rules of procedure to learn, reasons and principles for the process to understand, and further related studies to make, in order to enrich or strengthen the content of the subject matter and practical results gained. To illustrate, suppose that the manipulative process to be taught were the addition of limestone in soil improvement. The rule of the process, briefly stated, would be, "Apply from two to three tons of ground limestone per acre upon land where needed, once in each four year rotation"; the reasons or principles involved, briefly stated, "Limestone corrects soil acidity, a condition unfavorable to plant growth. It also improves the physical condition of the soil." Further related studies may well lead to "a study of the history of the use of limestone in agriculture, some results at the various experiment stations, and the methods used."

While all three of the above aspects of the study are a part of the vocational methods to be used, the strictly vocational point of view would emphasize the first, or the rules of procedure, not only learned but carried out to assure skill in the manipulative processes. We would not stop here at the mere "rule of thumb." While this must be learned, vocational efficiency and progress require that the student pursue his training into the realm of reasons, principles and related studies. It is just here that general science may tie up at every point in vocational education, as a reference study, to give reasons, explain principles, and lead into related matter, for every manipulative process of all the vocations under the Vocational Education Act. The organization of the subject matter of general science, under this plan, is around the job, and its processes. We have scarcely time to be interested in the varying discussions of the organization of general science upon any other basis. A glance through one of the many general science books shows, as one topic, the "air as a substance related to animate and inanimate matter." In our study of vocational agriculture, when we are concerned with the manipulative processes of handling soil, feeding animals or plants, we shall refer to the subject matter of such a chapter to find our reasons and principles for such processes as are affected by air; and so on with water, light, heat, and the other common things and processes entering into the study of general

science, and the environment of the vocations. There may be much of the subject matter of our general science texts that can not well be considered as one or both of the "two r's" in the above plan of vocational instruction. I believe, however, that any of our standard general science texts may be used as a constant source of excellent reference material to give principles and enriching related studies for all the manipulative processes in the jobs of the major vocations.

I would not imply by this discussion that there is no other use for General Science except as a reference in curriculums of vocational education. Early in the courses, either in the junior high school or in the first year of the four-year high schools, general science should be a required study in all vocational courses. It should precede or parallel the vocational courses as a separate subject, for either one or two years. Speaking from an agricultural point of view, I favor two years of general science paralleling the first two years of vocational agriculture, and I hope that the leaders in vocational education and the leaders of science may soon get together on a program of general science that will strengthen and support our work in vocational education at every point, and thus enable us both to use our subjects for the highest service of the boys and girls whom we are training for useful, happy and efficient citizenship.

CLASSROOM SAYINGS.

What is smoke and how may it be prevented?

Smoke is caused by the carbon in the wood and it can be prevented by taking the carbon out.

What is a calorie?

Calone is a perfume which we get from the city of Calone in France.

Dew is the light-frost and is formed over night by the dampness. It is the light-frost that has not been frozen over.

Specific heat is the particular way molecules cling more closely together.

Gravitation is air pressure.

Dew is the evaporating of air or dew point.

Three ways of transmitting heat are: Concussion, confusion and friction.

Three ways of transmitting heat are curvilinear motion as sun's rays, rectangular, straight as heat from a furnace, and by pressure, put a pressure on rubber it becomes hot.

Three ways of transmitting heat are by earth, sun and plants when eaten.

The draft of a chimney is as follows: The chimney is open at the top, the pipes lead from the stove into the chimney where it is forced out into the air.

550 foot pounds is the power a horse uses every time he lifts one foot.

THE MATH QUEST.

By Helen Whitaker,

Topeka, Kansas.

Cast of Characters: Algebra; The Alphabet, twenty-six girls; *ten X's,* ten girls; *three −X's,* three boys; *Numbers 0 to 9,* ten boys wearing crowns with numbers in front.

Scene—An opening in the woods. (*Algebra enters.*)

Algebra—In sooth, I know not what the number is—
That subtle number, it eludes me still,
And how to catch it, find it, or come by it,
I know not. With this care I am distraught;
I've searched the woods to find the answer there.
I've peered in books for method, hint or guide,
And every disappointment makes me fear
Fortune doth mock my venture and withhold
The mystic number that the queen demands.
"Bring me the number, ere again you come
Whose square, when lessened by its seventh sum,
Is then worth naught." And I have failed!
But no, there's someone else I'll ask.
I'll call my letters forth to aid the task.

(*The Alphabet enters at her call.*)

O Alphabet, when last from all our realm
We met to crown a Queen, our Queen of May,
She gave to all her subjects some great task
To do for her. That was a year ago.
And now today I fain would greet her court,
But am forbid—my task's not finished yet.
For this I seek your aid. Thus spake the Queen,
"Find me the number, ere again you come,
Whose square when lessened by its seventh sum
Is then worth naught." Now hasten to the task,
And make all speed to find me what I ask.

(*Letters march and form a figure eight, kneeling on the grass.*)

'Tis wrong, what you suggest.
"8" will not end our quest.

(*They try again, this time forming a four.*)

That's not the one I need,
But one more trial—Proceed.

(*Letters form a ten.*)

Nay, nay, that will not do. It is not right.
'Tis not the number that the Queen desires.

But thou, fair X, art wiser than the rest—
I beg you stay.
The rest away.
I have no further need of you today.

(*Alphabet exeunt, all but X.*)

Now, X, bring aid.
On you is laid
The task the Queen did ask of me.
"Find me the number—seek it with great care—
Whose seventh sum, while it makes less the square,
Doth equal naught." This, the Decree.

(*While she speaks, the ten other X's enter. They come quickly up to X, and she joins herself to them.*)

These ten strange X's joined to mine, I see
Have made the sum of X's eleven, for me.

(*Enter three* $-X$*'s. They are joined by three of the girls, and wander off together.*)

These minus X's through an adverse fate
Have changed the total number back to eight.
Alas, 'tis ever thus with girls in Math.
My problems and my theory they forsake
When men are near. 'Tis many an hour they waste
In talking, roaming care free through the wood.
As to the rest, my faithful eight, to you
I give the task: to find the answer true.

(*Enter the Number System.*)

Welcome, O Number System, to our land.
Whence come ye, and what seek ye at our hand?

Zero— We come from far, in search of lady fair,
One X, whose name is honored in the realm
Of Math, wherever Algebra is known.
Under her rule, her subjects, would we be.

Algebra—Yonder she stands, my friend and helper, she.

(*Number System leads X to one side, 2 puts his crown on her, they help her onto a log, and all hail her as queen.*)

Algebra—Look now, what do I see? X raised to power.
The Numbers crown her, seek her for their Queen
And place upon her head their crown of two,
The index of her power. By a log
They've raised her thus above the other X's.
She's now the square of what before she was.
The square—the SQUARE—why now I see—

She is the first part of the Queen's decree.
And for the rest, the sum of X's left
Is seven. If this be naught, my X is the one
Whose square when lessened by its seventh sum
Is then worth naught.

Zero— I am but naught; if any help I'd be
In your great search, I'm ready for the task
And I'll be equal to whate'er you ask.

Algebra—Come all, according to the Queen's decree
Let me find out what number X may be.

(*They form the equation:* $x^2-7x=0$ *with X first, then the seven X's in a row and last Zero, holding the minus and equality signs in their proper places.*)

Algebra—X square minus seven x is naught. Yes, true.
When this is solved, my task indeed is through.

(*She waves her wand. In the confusion following, X is uncrowned. She takes 0 and 7 by the hand and brings them to Algebra.*)

Algebra—My problem solved. Two answers do you bring—
Seven and Naught. Yes, I receive them both:
For both fulfill the Queen's desire of one
Whose square, when lessened by its seventh sum
Is then worth naught.
Rejoice with me, my task is now complete.
In joy and honor to the court we'll go,
And there these wise solutions proudly will we show.
Come one, come all,
Away, away,
To the court of our Queen,
Our fair Queen of May.

A PROJECT IN ELECTRICITY FOR HIGH SCHOOL PHYSICS.

By Hiram W. Edwards,
University of California, Berkeley.

The following article is written for the purpose of suggesting to teachers of science classes a project which is centered about the construction of a multi-range voltammeter.

The object of the project is twofold. For the student, it presents a problem that challenges his ability to solve, establishes satisfaction in the making of a thing that is useful, instills an appreciation of good instruments and fosters the training of skill with the hands. For the school, it supplies a much needed piece of apparatus at a very small cost.

Several of these instruments have been made by students in classes under the supervision of the writer, which have ranges of 0-15. and 0-1.5 volts and amperes. The finished product has been found to be serviceable as a sensitive galvanometer in such work as measurement of resistance by the wheatstone bridge. The cost has varied from fifty cents to a little more than a dollar.

The nucleus of the instrument consists of a moving coil type of ammeter such as is found in many automobiles. These have been obtained from dealers in the parts of wrecked automobiles. The price varies somewhat with the ability of the buyer but should be purchased for not more than one dollar. As a rule nothing more than slightly worn pivots will be found requiring adjustment.

Other materials needed will be a few inches of copper wire, from 200 to 1250 ohms of No. 36 german silver wire, and a few binding posts. A small board will be found convenient upon which to mount the instrument, its coils and shunts.

The method of construction is essentially as follows:

1. An inspection of the instrument will have to be made to insure freedom of the moving parts. Defective connections should be remedied. On account of the wear on the ends of the pivot, the screws holding the jewelled bearings should be turned in a little.

2. The old shunt will have to be removed. This is usually soldered to the screw binding posts and is easily taken off.

3. The instrument should be mounted on a small board with its face in a vertical position. Mounted in this manner it is easy to place shunts on the binding posts or to connect the resistance coils of the voltmeter to one of the posts. Without shunts or coils the instrument is ready to be used as a detector of small currents by connecting the binding posts directly to the circuit. When used as a galvanometer care must be taken not to let any but small currents pass through it, or the springs will be destroyed.

4. To extend the range of the instrument as a voltmeter, it will be found convenient to have two coils made from high resistance wire. On account of the large number of different types of ammeters which may be used for this purpose it is impossible to say how much resistance will be required for each coil. The resistance needed should be determined by trial so that when one of the coils is connected in series with the instrument one volt will give a deflection of one scale division. The

other coil may be adjusted to give a deflection of ten scale divisions for one volt. If a reliable voltmeter is not available for calibration by comparison, then a Daniell cell, which gives a pressure of 1.1 volts, will be found convenient. When the adjustment is completed it is best to mount the coils on appropriate spools provided with binding posts so that proper connection to the instrument may be quickly made.

5. The shunts for the ammeter may be made from short pieces of copper wire. The exact length of one will have to be determined by trial so that when one ampere is passing through the circuit that a deflection of one scale division is produced. The length of the other shunt should be such that one ampere will give a deflection of ten scale divisions The ends of the wires serving as shunts should be soldered to copper or brass washers which have had slots cut from one side to permit easy placement on the binding posts. The washers should be securely clamped on the binding posts between two nuts, one of which should be soldered to the binding posts. After completion each shunt should again be carefully tested for accuracy. Care must be taken to prevent any large current from passing through the moving coil of the instrument when a shunt is not in place.

The completion of an instrument such as is described briefly above will ordinarily take about three hours. The writer considers the results achieved well worth the time required.

BITUMINOUS COAL INDUSTRY.

At the February meeting of the American Institute of Mining and Metallurgical Engineers in New York the afternoon session on Tuesday, February 17, was devoted to a discussion of the bituminous-coal industry. The fluctuations in production and their extent and causes were discussed in a paper by George Otis Smith, Director of the United States Geological Survey, Department of the Interior, and F. G. Tryon, the coal statistician of the Survey. The statistical facts collected by the Survey during the last 30 years were graphically set forth in a dozen diagrams and certain broad conclusions were drawn from these facts.

The "bad load factor" of the soft coal mines of the country shows itself in the annual, seasonal, and daily fluctuations in coal production. On the average, during the past 30 years the mines have been idle 93 working days in the year.

The national interest in bettering the load factor of the soft-coal industry is measured by the fact that we have an excess mine capacity of at least 150 million tons and an excess labor force of perhaps 150,000 men. In terms of man-days, universal military training of our young men for three months would cost the nation less than the present enforced idleness in coal mining.

THE THEOREM OF NICOMACHUS.

By Oscar Schmiedel,

Parsons College, Fairfield, Iowa.

The article on "Useful Benefits from Study of Mathematical History," on page 463 of the May number of this journal, has been made the subject of criticism on page 663 of the October number. The aim of the criticism, if I understand aright, is to show that the theorem in the May number, which says, that any power of an integer is expressible as a sum of consecutive odd numbers, is a mere special case of the more general principle, that the product of two integers is similarly expressible.

A few minor points, where the meaning is not clear, should be noticed first. We ask: Should we not be grateful for any facts preserved for us in history which, though trivial in themselves, may throw a light upon the intellectual attainments of those distant ages? And are not often such facts thought trivial merely because they stand dissociated from the causes that gave rise to them, and because they have been disregarded by later writers, and are they not therefore often of the kind of uncompleted problems mentioned? Why "charity" for Nicomachus? The Pythagorean philosophy made number the essence of all things[1]; the universe, as one vast harmony, itself was number, and virtues resided in numbers. Nicomachus, who first compiled arithmetical knowledge into a system, and wrote the Elements of Greek arithmetic, was a Pythagorean, who believed in the doctrines of the school and labored to perpetuate them. He does not hesitate confessing pleasure in facts of his own discovery, though trite and void of any importance as seen in the light of present-day knowledge, as when he found the difference between the heteromecic and square numbers to be the natural numbers: $2-1, 6-4, 12-9, \ldots$ respectively, $1, 2, 3, \ldots$. Is it hard to conceive that he should pride himself upon his discovery of a new relation between numbers similar to that important one due to the Master; and should deem it important, too? However, he is innocent of the charge; and yet, he certainly must have thought his theorem of sufficient importance to have it transmitted, and history transmitted it. History speaks of it as "pretty"[3]; as "extraordinarily interesting"[4] on account of its application to the summation of the cubes of numbers; as an "important proposition."[5]

The importance of a thing is relative. What yesterday shone bright with promise, may today sink into insignificance, and tomorrow, when the constellations change, resume its former lustre. Importance may inhere in directive propensity.

That the enlarged theorem which extends the forms given by Pythagoras and Nicomachus to any powers of integers should be a half-truth only is not certain. On the contrary, the theorem appears complete and independent in itself. Nor can it be admitted that the terms of the development must necessarily be found by considering the average of the sum of terms, which procedure, it is said, would obviate elaborate calculation. The terms are found quite in the manner indicated in the article itself. Manifestly, 16 is the fourth part of the product $4 \cdot 16$, and hence of the sum equivalent to that product, i. e., the average of the sum of all the terms. But how, without further calculation, the terms themselves are found from this average is not revealed. How is the first term to be

[1] *Biographie Universelle*, vol. 34, Pythagore.
[2] M. Cantor, *Geschichte der Mathematik*, I, 429.
[3] G. H. F. Nesselmann, *Die Algebra der Griechen*, page 210.
[4] Cantor, page 432.
[5] F. Cajori, *History of Mathematics*, Ed., 1917, page 32.

found for the product 4·1? How for 4·25? The rule stated might answer when the sum is given and the product to be found; but to cover this entire phase of the question well, it should be supplemented by some statement such as this: The first term of the sum is the difference of the factors increased by 1, the last their sum decreased by 1.

Will the writer of the criticism be consistent and call his own principle a half-truth if it should appear that it, too, is but a part of a more comprehensive one? It has already been suggested where his statement is deficient. Would b in the product $4 \cdot 25 = -\frac{11}{4} - \frac{3}{4} + \frac{5}{4} + \frac{13}{4}$ be odd or even? His principle, in order to include this case, might suitably be generalized and stated thus: The product of two numbers, one of which, a, is an integer, the other, b, any number whatsoever, may be written as a sum of terms with a common difference, 2, e. g., $4 \cdot 1 = -2+0+2+4$; or, as a formula:

$$ab = (b-a+1) + (b-a+3) + \ .\ .\ .\ + (b+a-1), \qquad (1)$$

from which the rule for the first term may be abstracted as above. But must the difference be 2?

It may be noticed in this sum that b occurs in every term and, there being a such terms, the b's alone will give the product, ab; hence the aggregate of all the quantities combined with b must vanish. This suggests that the a terms of the sum may be composed in any manner whatsoever, only so that b appears as term in each, and the sum of all the other quantities is zero. Thus, the square of 5 may be expressed as a sum of five successive integers:

$$\begin{aligned} 5^2 &= (5+5+5+5+5) + (-2-1+0+1+2) \\ &= 3+4+5+6+7. \end{aligned}$$

The simplest case for a common difference among the terms occurs where the difference is 1, and the development as a formula will be:

$$ab = [b+\tfrac{1}{2}(1-a)] + [b+\tfrac{1}{2}(3-a)] + \ .\ .\ .\ + [b+\tfrac{1}{2}(a-1)]. \qquad (2)$$

In general, for a common difference, r:

$$ab = [b+\tfrac{r}{2}(1-a)] + [b+\tfrac{r}{2}(3-a)] + \ .\ .\ .\ + [b+\tfrac{r}{2}(a-1)]; \qquad (3)$$

where r may be any integer, including 0. Of all the values r may have, only one, namely 2, is needed to give the form set forth.

But more: This difference, so far taken constant, may change from term to term, and yet produce a sequence of which (1) is a special case. Thus, $4 \cdot 5 = 4+6+5+5 = -7-1+8+20 = -23-14+10+50$, etc., all lawful sequences the general term of which is:

$$\begin{aligned} ab = {} & [b-(a+n)^n + (n+1)n^n] + [b-(a+n)^n + (n+1)(n+1)^n] + \ .\ .\ . \\ & + [b-(a+n)^n + (n+1)(n+a-1)^n], \qquad (4) \end{aligned}$$

where m^n stands for the binomial coefficient defined as:

$$m^n = \frac{m(m-1)\ .\ .\ .\ (m+n-1),}{1 \cdot 2.\ .\ .\ .\ n}$$

If in (4) the quantities following b in each term be multiplied by r, [illegible] resulting form will be more general yet. By taking r and n each equal 1, the form will again result from it as special case.

All that has been said so far refers to products with two factors only. Now the product $abcd$ . . . to n factors might be developed; then taking $n = 2$, that same principle will appear a special case also of this. And so on in endless variety.

Once more: The assertion is made that Nicomachus' theorem has no foundation as a mathematical principle. If his be true, theo, whatever be the meaning of the declaration, it would equally apply to the extended theorem given in the form:

$$a^n = (a^{n-1} - a+1) + (a^{n-1}-a+3) + \ .\ .\ .\ + (a^{n-1}+a-1).\qquad (5)$$

[*]

Should it now prove possible to derive (1) from (5), would the principle be held to be without foundation as a mathematical principle?

But this can be done, since (5) is a function of two parameters, a and n, and therefore expressible in terms of other two parameters, as a and b. Assuming $b = a^{n-1}$, and making the substitution, at once leads back to (1); and the case is proven.

For illustration let $a = 4$, $b = 2/3$; and n in (5) will be $= \frac{1}{2}(3 - \log 3/\log 2)$, or .75 approximately. Development by (1) gives:

$$4.2/3 = -7/3 - 1/3 + 5/3 + 11/3.$$

Now granting all this as true and to the point, the statements in the May number retain their validity and still represent what it had been intended they should represent: an effort to illustrate the value of historic study by the generalization of the theorems of Pythagoras and Nicomachus in the sense and form of their discoverers.

Entirely similar criticisms might have been advanced on the formula at the bottom of page 463, which is:

$$a^n = (a^{n-m} + a^m/2)^2 - (a^{n-m} - a^m/2)^2; \qquad (6)$$

for Euclid has the identity

$$ab = (a + b/2)^2 - (a - b/2)^2,\text{[7]} \qquad (7)$$

from which (6) may be derived.

On the other hand, (7) may be derived from (6) by assuming $b = a^{n-1}$ and $m = 1$. Other values of m will give relations not directly found in Euclid's form. Hence (6) appears the more general of the two. Thus, to develop 5^2, let m in (6) be 2, and the result is: $5^2 = 13^2 - 12^2$; while (7) gives only the palpable identity $5^2 = 5^2$.

By proper choice of n and m, (6) will yield the identity:

$$a^n = (a^n + 1/2)^2 - (a^n - 1/2)^2, \qquad (8)$$

giving the nth power of a number in terms of squares of numbers which differ by unity and the sum of which is that same power; as, $5^3 = 63^2 - 62^2$; or the identity:

$$4a^2 = (a^2 + 1)^2 - (a^2 - 1)^2, \qquad (9)$$

which is Plato's form for integral values of the sides of right triangles; or many more.

History does not relate how Pythagoras came to discover the relation between the sides of the right triangle. But having knowledge of the theorem that the sum of consecutive odd numbers is the square of a number; and having deduced from it the relation of numbers expressed in a general way by (6), from which sets of integers could be computed such that the sum of the squares of two of them would give the square of a third; and considering the fact already familiar that one of these sets, 3, 4, 5, may represent the sides of a right triangle, it is easy to conceive how he should have been led to experiment with other sets for the same purpose; and finding his surmise confirmed, after many trials more perhaps, succeed to a rigorous geometrical proof of that theorem of unquestioned importance according to which the sum of the squares of the sides of a right triangle is always equal to the square of the hypothenuse.

This "the student of history is compelled . . . to believe" was the course[8] by which that fundamental theorem came to light; and thus the common observation is confirmed that simple truths, themselves of not too great utility, may play a role of great importance in new discoveries.

It is known that Sir Isaac Newton felt his way to the binomial theorem by experimenting with such trivial things as the sets of numbers: 1, 1; 1, 2, 1; 1, 3, 3, 1; etc., with the expressed design of ascertaining if a universal law could be established that would uniformly give these numbers one from the other in succession; and that he thus intuitively arrived at

[6]*Cantor, Geschichte, Vol. I*, page 432, footnote 2.
[7]*Elements*, Bk. X, Th. 29, Lem. I.
[8]Tropke, *Geschichte der Elementar-Mathematik, Vol. II*, page 71.

the general form $n/1\cdot(n-1)/2\cdot(n-2)/3\cdot\cdot\cdot$, and thence the binomial theorem.

It is this process of inductive reasoning, this procedure from special cases to general laws, the article in the May number meant to emphasize and set it forth as under contribution to the study of history.

PROBLEM DEPARTMENT.

Conducted by J. A. Nyberg.

Hyde Park High School, Chicago.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and solve problems here proposed. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. If you have any suggestion to make, mail it to him. Address all communications to J. A. Nyberg, 1044 E. Marquette Road, Chicago.

SOLUTION OF PROBLEMS.

631. *A solution by Katherine S. Arnold, Milwaukee-Downer College, was received too late for publication.*

639. *A solution by Hazel C. Jones, Danville, Ill., was received too late.*

641. *Proposed by Walter R. Warne, State College, Pa.*

Eliminate x between the equations

$$x+1/x=y$$
$$x^5+1/x^5=z.$$

Solution by N. Anning, Orono, Me.

$$\begin{aligned} y^5-z=(x+1/x)^5-x^5-1/x^5 &= 5[(x^3+1/x^3)+2(x+1/x)] \\ &= 5y(x^2-1+1/x^2+2) \\ &= 5y(y^2-1) \\ &= 5y^3-5y. \end{aligned}$$

Eliminant: $z=y^5-5y^3+5y$.

Note: If $y=2\cos\theta$, $z=2\cos5\theta$.

Also solved by Henry Ruzicki, St. Martins College, Lacey, Wash.; H. C. Whitaker, Philadelphia; C. E. Githens, Wheeling, W. Va.; Ethel Snider, Piermont, N. Y.; A. Pelletier, Montreal, Can.; irrational forms of the eliminant were found by Walter R. Warne, by Thomas E. N. Eaton, Redlands, Calif., and by R. T. McGregor, Elk Grove, Calif.

642. *Proposed by Abigail Glenn, Student, Chicago Normal College.*

What value of b will make b^4+30b^2+25 a perfect square?

I. *Solution by A. Pelletier, Montreal, Can.*

Let $b^4+30b^2+25=(b^2+x)^2$

Then $b^2=(x^2-25)/(30-2x)$

There being no restriction as to the nature of the values of b, we may give to x any value, and then determine b.

Also solved similarly by Herbert C. Whitaker, Philadelphia.

II. *Solution by Walter R. Warne.*

Assume $b^4+30b^2+25=(pb^2+5)^2$, p arbitrary,

Then $b^2=10(p-3)/(1-p^2)$. When $p=\pm1$, the formula fails.

Also solved by N. Anning. The trivial solution $b = 0$ was sent in by three contributors and the special values $b = 2\sqrt{3}$, 6 by another. A second solution by N. Anning is very interesting:

III. Comparing b^4+30b^2+25 with the left-hand side of the algebraic identity,

$$(2xy+6y^2)^2+6(2xy+6y^2)(x^2-y^2)+(x^2-y^2)^2 = (x^2+6xy+y^2)^2,$$

we see that the given expression is a perfect square if

$$b^2 = 2y(x+3y),$$
$$5 = x^2-y^2.$$

Let $x+y = 5k$, where k is any rational number except 0, and $x-y = 1/k$,

$$x = (5k^2+1)/2k, \quad y = (5k^2-1)/2k,$$
$$b^2 = 2y(x+3y),$$
$$= (5k^2-1)(10k^2-1)/k^2.$$

And, putting k^2 = the positive rational number, p,

$$b^2 = 50p-15+1/p.$$

Check: When $p = 1$, $b^2 = 36$ and $b^4+36b^2+25 = 49^2$
When $p = 1/5$, $b^2 = 0$ and $b^4+36b^2+25 = 5^2$
When $b^2 = 50p-15+1/p$, then
$$b^4+30b^2+25 = (50p-1/p)^2.$$

643. *Proposed by Walter R. Warne, State College, Pa.*

The sum of three terms of an harmonic series is 11, and the sum of their squares is 49. Find the numbers.

Solution by Thos. G. Brown, Boys' Technical High School, Milwaukee.

Terms of series
$a, b, c,$
Then $b = 2ac/(a+c)$,
By hypothesis

$$a+2ac/(a+c)+c = 11 \text{ or } 2ac/(a+c) = 11-a-c \qquad (1)$$

and

$$a^2+[2ac/(a+c)]^2+c^2 = 49 \text{ or } [2ac/(a+c)]^2 = 49-a^2-c^2 \qquad (2)$$

Substituting (1) in (2) and simplifying

$$a^2+c^2+ac-11(a+c)+36 = 0 \qquad (3)$$

Clearing (1) of fractions and subtracting from (3)

$$-3ac+36 = 0$$

or

$$c = 12/a \qquad (4)$$

Substituting (4) in (1)

$$a^2+144/a^2+48-11(a+12/a) = 0,$$

Whence

$$(a+12/a)^2-11(a+12/a)+24 = 0,$$

Whence

$$a+12/a-8 = 0, \quad a+12/a-3 = 0.$$

Solving

$$a = 6,\ 2,\ (3+\sqrt{-39})/2,\ (3-\sqrt{-39})/2$$
$$b = 3,\ 3,\ 8,\ 8,$$
$$c = 2,\ 6,\ (3-\sqrt{-39})/2,\ (3+\sqrt{-39})/2,$$

Also solved by N. Anning, and A. Pelletier. Incomplete solutions in so far as the irrational values were omitted were sent in by Thomas E. N. Eaton, Ethel Snider, C. E. Githens, R. T. McGregor, Herbert C. Whittaker, Philadelphia, and Katherine S. Arnold. The Proposer also solved it ingenuously by using the relation $a/c = (a-b)/(b-c)$.

644. *Proposed by H. C. Peterson, Chicago.*

Suppose a rectangular strip of paper with vertices A, B, C, D, consecutively (AB representing the length). Fold on some line, say EF (E on AB, F on CD) so that EA will intersect FC in point G, say, making EFG an equilateral triangle.

Solution by A. Pelletier, Montreal, Can.

We have simply to draw EF so that $\angle AEF = 60°$. In order to have

an intersection G, we must have $AE \geq 2AD/\sqrt{3}$ and $EB \geq AD/\sqrt{3}$. Hence, there is no solution when $AB < AD\sqrt{3}$, one solution for $AB = AD\sqrt{3}$, and an infinite number for $AB > AD\sqrt{3}$.

Also solved by Ethel Snider.

645. *Proposed by Walter R. Warne.*

If $abcs = 8\triangle^2$, where a, b, c represent the sides of a triangle, s the semiperimeter and $\triangle$ the area, prove the triangle is equilateral.

I. *Solution by Norman Anning, Orono, Maine.*

$$abcs = 8\triangle^2$$
$$= 8s(s-a)(s-b)(s-c).$$
$$abc = (b+c-a)(c+a-b)(a+b-c).$$

Expanding and recombining,

$$a^3+b^3+c^3-b^2c-bc^2-c^2a-a^2c-a^2b-ab^2+3abc = 0$$
$$(s-a)(b-c)^2+(s-b)(c-a)^2+(s-c)(a-b)^2 = 0.$$

Now, since a, b, c are the sides of a triangle, $s-a$, $s-b$ and $s-c$ are positive and $(b-c)^2$ etc., cannot be negative. Consequently,

$$b-c = c-a = a-b = 0$$

and the triangle is equilateral.

Also solved by A. Pelletier. C. E. Githens proved the converse of the problem.

II. *Comment by Herbert C. Whitaker, Philadelphia.*

The following relations between the parts of any triangle are well known,

$$4\triangle R = abc$$
$$\triangle = rs$$

Multiply these and the given equation

$$R = 2r.$$

Now it is necessary in an equilateral triangle that the radius of the circumscribed circle should be twice the radius of the inscribed circle, but I do not think that the relation $R = 2r$ is sufficient to establish that the triangle is equilateral.

PROBLEMS FOR SOLUTION.

656. *Proposed by F. A. Cadwell, St. Paul, Minn.*

ABC is an isosceles triangle, $AB = AC$; and AE is a line not cutting the sides of the triangle. A point D on AE is chosen so that $BD = BC$ and $\angle ADB = 150°$. Prove $\angle DAB$ is one-third of $\angle DAC$.

657. *Proposed by Walter R. Warne.*

If $x^2 = a^2+b^2$, $y^2 = c^2+d^2$, show that $xy > (ac+bd)$.

658. *Proposed by J. A. Nyberg, Hyde Park High School, Chicago.*

Given two points A and B. Find, using only dividers, two points C and D, so that ABCD (in order) will be the corners of a square.

659. *Suggested by H. C. Whitaker's comment on problem 645.*

Prove geometrically that if $R = 2r$, the triangle is equilateral.

660. *Proposed by Martha G. Lathrop, Emmett, Idaho.*

Given three unequal non-intersecting circles O, O,′ O″. Let A be the intersection point of the common external tangents of O and O′, B the point for O′ and O″, C the point for O″ and O. Prove A, B, and C are collinear.

ARTICLES IN CURRENT PERIODICALS.

American Bot nist, for February; *Joliet, Ill.; $1.50 per year, 40 cents a c py:* "Plant Names and their Meanings," Willard N. Clate; "Wild-flower Distribution in the West," Blanche H. Soth.

Am rican Journal of Botany, for February; *Brooklyn Botanic Garden, Bro klyn, N Y.; $6.00 per year, 70 cent a copy:* "Effect on Chestnuts of Substances Injected into Their Trunks," Caroline Rumbold; "Subalpine Lake-Shore Vegetation in North-Central Colorado," Francis Ramaley; "Some Observations on the Spore Discharge of Pleurage Curvicolla (*Wint.*) Kuntze," J. L. Weimer; "Correlation Between Size of the Fruit and the Resistance of the Toma o Skin to Puncture and Its R lation to Infection with Macrospo ium Tomato Cooke," J. Ros nbaum and Charles E. Sando.

American Math matical Monthly, for March; *Lancaster, Pa.; $3.00 per year, 35 cents a copy:* "Fou th Annual Meeting of the Mathematical Association of America," Professor W. D. Cairns; "The November Meeting of the Illinois Section," Dr. E. B. Lytle; "Questions and Discussions," "Recent Publications," "Problems and Solutions."

Condor, for January-February; *Berkeley, California; $2.00 per year, 40 ents a copy:* "Autobiographical Notes" continued), Henry W. Henshaw; "Importance of the Blind in Bird Photography" (with six photos), Frank N. Irving; "The Rusty Song Sparrow in Berkeley, and the Return of Winter Birds," Amelia S. Allen; "A Peculiar Feeding Habit of Grebes," Alexander Wetmore; "A Return to the Dakota Lake Region" (continued , Florenc M. Bailey; "Notes on the Limico ae of Southern British Columbia," Allan Bro ks.

Journal of Geography, for February; *Broadway at 156th Street, New York; $1.00 per y ar, 15 cen s a copy:* "Suggestions for a Study of Latin America Based Upon Our Trade Relations," E. Curt Wal her; "Problem Teaching: How to Plan for It," Ruby Minor; "The National Council of Geogra hy Teachers," George J. Miller.

L terary D gest, for March 13; *354 Fourth Ave., New York City; 10 cents a copy:* "Labor's Verd ct on Proh bition"; "What to Hope from the Railroads"; "The Steel Trust Finds it Pays to Be Good"; "Our S ake in the Adriatic"; "Lenine's Puzzling Peace Offer"; "Labor Awakening in Japan"; "Ca ada's Voice in the League."

National Ge graphic Magazine, for March; *Washington, D. C.:* "Massachusetts—Beehive of Business" (41 illustrations), William J. Showalter; "Fo mosa the Beautiful" (60 illustra ions), Alice B. Ki jassoff.

Nature Study Review, for Feb uary; *Ithaca, New York; $1.00 per year, 15 cents a copy:* "A Neglected Side of Nature Study," S. C. Schumaker; "Th Relation of Nature Study to Boys and Girls Club Work," Theodosia Hadley; "Additional Scienc Tests in the Grades," E. R. Dow ing; "The Co nell Rural School Leaflet a d Conservation," E. L. Palmer; "Geography and Life," A. B. Comsto k.

Photo-Era, for March; *Boston, Mass.; $2.00 per year, 20 ents a copy:* "How to Know Your Best Photographs," Winn W. Davids n; "Odd French Co ners for the Camerist," Herbert B. Turner; "Home-Portraiture —Dealing with Sunshine," Wilson Todd; "Save It!" Frede ick C. Davis; "Some Critics on 'L keness' in Portraits," The British Journal; "An Actor and His Hobby," Hamilton Revelle; "How I make My Bromoil-Prints," G. Bellam Clifton.

Physical Review, for February; *Ith ca, New Yor ; $7.00 per year, 75 ents a copy:* "The Nuclei of Atoms and the New Periodic System," W. D. Harkins; "The Bohr Theory and the Approximate Harmonics in the Infra-Red Spectra of Diatomic Gases," Edwin C. Kemble; "Reflection and Transmission f Ult a-Violet Li ht by Sodium and Potassium," Mabel K. Frehafe .

Popular Astronomy, for March; *Northfield, Minn.; $4.00 per year:* "Occultation of Satellite I by Satellite III, in the Jovian System" (with Plate VIII), George H. Hamilton; "First Study of Heavenly Bodies," Lesson III, Mary E. Byrd "On the Solar Radiation," Jason J. Nassau; "The Use of Selenium Cells in Astronomy," Lewis J. Boss; "Astronomy in the High School," Ruby B. Albert; "A New Theory of the Deluge," H. P. Lee; "Astronomy in Daily Life," Gilbert P. Chase.

School Review, for March; *University of Chicago Press; $1.50 per year, 20 cents a copy:* "The Washington Junior High School, Rochester, New York," R. L. Lyman; "The Individual Pupil as the Unit of Supervision in High Schools" Morton Snyder; "Junior High-School Study Tests," Charles E. Finch.

Scientific Monthly, for March; *Garrison, New York; $5.00 per year, 50 cents a copy:* "Space, Time and Gravitation," Edwin B. Wilson; "The Need for a More Serious Effort to Resume a Few Fragments of Vanishing Nature," Dr. Francis B. Sumner; "The Origins of Civilization," James H. Breasted; "The Mechanism of Evolution," Edwin G. Conklin; "A Graphic Method of Measuring Civilization and Some of its Applications," Dr. Roland M. Harper; "Finis Coronat Opus," Frank V. Morley; "On Rhythm," D. Fraser Harris; for April: "The Beginnings of Human History Read from the Geological Record—The Emergence of Man," John C. Merriam; "The Measure of Excellence in Scientific Activity," R. D. Carmichael; "The Relation of Philosophy and the Sciences," G. R. Wells; "Why Does Our Public Fail to Support Research?" T. D. A. Cockerell; "Science and the State," Dr. William Salant; "Inertia," Sir Oliver J. Lodge; "The Mechanism of Evolution," Professor Edwin Grant Conklin; "A Nature Drama," H. L. Fairchild.

BOOKS RECEIVED.

Infinitesimal Calculus, by F. S. Carey, University of Liverpool. Pages x+352+ix, 14×22 cm. Cloth, 1919. $4.25. Longmans, Green & Company, New York.

Plane Trigonometry for Secondary Schools, by Charles Davison King, Edard's High School, Birmingham. 334 pages. 13×19.5 cm. Cloth, 1919. The University Press, Cambridge, Eng.

Modern Junior Mathematics, Books I and II, by Marie Gugle, Assistant Supt. of Schools, Columbus, Ohio. Pages ix+222; xiv+239. 13.5×19 cm. Cloth. 1920. The Gregg Publishing Company, New York.

Second Course in Algebra, by Walter B. Ford, University of Michigan, and Charles Answerman, McKinley High School, St. Louis. Pages ix+299. 13×19 cm. Cloth. 1920. $1.28. The Macmillan Company, New York.

Word Study for High Schools, by Norma L. Swan, Long Branch High School. Pages xi+142. 13.5×19. Cloth. 1920. 72 cents. The Macmillan Company, New York.

Problems in Botany, by W. L. Eikenbery, University of Kansas. Pages xii+145. 14.5×21 cm. Cloth. 1920. 72 cents. Ginn and Company, Chicago.

Proceedings of the High School Conference, 1919, University of Illinois, by the High School Visitor. 313 pages. 15×22.5 cm. Paper. 1920. The University of Illinois Press, Urbana.

Physiology and Hygiene by Charles P. Emerson, University of Indiana, and George H. Belts, Northwestern University. Books I and II. Pages 188 and 323. 14.5×19. Cloth. 1919. Bobbs-Merrill Company, Indianapolis.

Physics, by Willis E. Tower, Englewood High School, Chicago, Charles H. Smith, Hyde Park High School, Chicago, Charles M. Turton, Bowen High School, Chicago, and Thomas D. Cope, University of Pennsylvania. Pages xv+492. 14×20 cm. Cloth. 1920. $1.35. P. Blakiston's Son and Company, Philadelphia.

South, by Sir Ernest Shackleton; a story of his last expedition, 1914-17. Eighty-eight illustrations and diagrams. Pages xxi+374. 15.5×23 cm. Cloth. 1920. $7.00. The Macmillan Company, New York City.

Pamphlets Received.

Bulletin No. 50, The Public School System of Memphis, Tenn. Parts 2, 3, 5, 6 and 7, Department of the Interior, Bureau of Education, Washington, D. C.

Bulletin No. 76, Community Americanization, by Fred C. Butler, Department of the Interior, Bureau of Education, Washington, D. C.

Bulletin No. 52, Industrial Schools for Delinquents, by H. R. Bonner.

Bulletin No. 69, Proceedings of the Fourth Annual Meeting of the National Council of Primary Education.

Bulletin No. 54, The Schools of Austria-Hungary by Peter H. Pearson.

Bulletin No. 58, Commercial Education by Glen L. Swiggett.

Bulletin No. 66, Training Teachers of Agriculture.

Bulletin No. 4, The Problems of Adult Education in Passaic, New Jersey.

The Work of the American Red Cross During the War, a Statement of Finances and Accomplishments for the Period, July 1, 1917, to February 28, 1919.

Journal of the Mathematical Association of Japan for Secondary Education.

Cornell University, The President's Report for 1918-1919.

PHYSICS TEST.

By C. P. Finger
Ferndale, Calif., Union High School.

Complete broken sentences, and answer questions with one word if possible.

Mechanics.

The inertia of a body is measured by its .... The resistance a body offers to being torn apart is .... The unit of capacity in the Metric System is the .... It is equal to......... smaller units known as............. One meter equals .... inches and one kilogram is equal to .... pounds. For tubes of small diameter, the elevation or depression of a liquid in them is .... proportional to .... Pascal's principle states that the pressure applied to an enclosed fluid is transmitted .... to every part of .... In a liquid the downward pressure is .... proportional to .... and is independent of .... Archimede's principle is stated as follows: A body immersed in a fluid .... The density of a heavy insoluble solid may be found by .... and .... and may be computed by dividing the .... by the .... Boyle's Law states that the .... of a gas varies .... The line described by a moving point is called its .... Rectilinear motion is exemplified by ....; rotary motion by .... and simple harmonic motion by .... A formula showing the relation between speed and time in variable motion is as follows:........ .... one showing relation between distance and time and acceleration in a freely falling body is .... and one connecting up velocity distance and acceleration is......... The gravitational unit of force (metric) is the .... The absolute unit is the .... and .... of the smaller units equals one ...., a larger unit. The resultant of two parallel forces in the same direction is .... and its point of application divides the line joining the points of application of the two forces into part which are proportional to .... Momentum is the product of .... and ....; Impulse is the product of and ....; Force may be expressed as the product of .... and .... For a simple pendulum the period is .... proportional to amplitude and .... to the length and .... to acceleration due to gravity. Work is measured by the product of .... and ....; and an English unit of work is the .... The absolute unit of work is the .... and a larger unit is the .... and is equal to .... of the smaller units. Potential energy is due to .... or a ....; Kinetic energy to .... and the kinetic form may be represented by the formula: The mechanical advantage of a machine is the ratio of .... to .... or the ratio of .... to the .... For an inclined plane this may be stated as the ratio of .... to .... The efficiency of a machine is the ratio of................ to ....

BOOK REVIEWS.

Psychology from the Standpoint of a Behaviorist, by John B. Watson, Johns Hopkins University. Pages XIII×429. 15x21.5 cm. Cloth. 1920. J. B. Lippincott Co., Philadelphia, Pa.

This is a most remarkable book and is treated in a most thorough and understandable way by one who is thoroughly competent to write upon this subject. The text is compiled in such a manner that any properly trained individual may read and understand the matter presented. The

success of the teaching in the future is going to depend very largely upon those instructors who have a good foundation and knowledge of human psychology and without this knowledge teachers will be a failure. The one wishing to become familiar with the physiological psychology of the human being cannot do better than to secure a copy of this book and make a thorough study of it. Justice cannot be done to the book in a short review.

There are eleven chapters in the text. Major paragraphs begin with bold face type which presents the subject to be discussed in these paragraphs. There are sixty-five splendidly executed half-tones and drawings. It makes interesting reading for the intelligent layman and progressiv- teachers should possess themselves with a copy. C. H. S.

Every Step in Canning by Grace B. Carr, Iowa State College. Pages 253 13×19.5 cm, cloth, 1919. $1.25. Forbes Co., Chicago.

A most valuable and interesting book devoted to the canning and preserving of fruit, meats, and vegetables, with special application to the cold pack method. This book will fill a great demand as it is one that every housewife, who is at all prone to do preserving, will be interested in to the extent of purchasing a copy. Perhaps the cost of living in her particular family may be reduced by carrying out suggestions given in this book.

There are nineteen chapters which are carefully written and will prove a great help to the housewife. The book abounds in recipes and gives explicit directions as to the best method of preserving food for future use. A list of firms from which materials needed in the preservation of eatables may be secured. C. H. S.

Catalogue of Spencer Microscopes, Microtomes, and Accessories. Pages 116. 17×25 cm. Paper. 1920. Spencer Lens Co., Buffalo, N. Y.

One of the finest gotten up catalogues of this character that has ever come to our desk. It gives very minutely the apparatus and supplies handled by this most excellent firm. It abounds in half-tones of their microscopes and other instruments which are splendidly executed and printed on the highest grade of calendered paper. The book reflects the character of reliability of this firm. The sections of apparatus are clear and understandable. Telegraph code, catalogue number, and dimensions of the apparatus are given. The prices are not given in the body of the catalogue, due to the fact that in these times there is almost a continual changing; there are, however, supplements which give prices the same as February 10, 1920.

School officers, instructors, and others who are interested in microscopes and microscopical instruments should possess themselves of a copy of this very excellent catalogue. C. H. S.

Brightness and Dullness in Children by Herbert Woodrow, University of Minnesota. 322 pages. 12.5×19 cm. Cloth. 1919. J. B. Lippincott Company, Philadelphia, Pa.

This volume of the series entitled Lippincott's Educational Guides, edited by Dr. W. F. Russell, augurs well for the series. It is the most comprehensive study of the nature and causes of differences in intelligence which has been published. It is particularly valuable for its careful analysis of the results of mental tests. It combines accuracy of statement, some originality of interpretation and a clear and readable style. There are certain details which, in the opinion of the reviewer, are open to debate, but in the important issues, the author's position agrees with the best evidence and opinion.

The book opens with a brief and simple exposition of the mental tests which have been devised in recent years and which constitute the instruments by means of which we are now able with much greater definiteness than formerly to distinguish degrees of brightness and dullness. The meaning of brightness and the ways of designating or expressing it are next discussed. The next three chapters treat of the bearing of physical factors on intelligence. It is dependent chiefly on the character of the brain, but is influenced by physical defects and related to the rate and stages of physical growth. Closely related to physical and mental growth is the advancement in school or pedagogical age.

Following this discussion of the bearing of physical factors on intelligence is a series of chapters which compare the various special or particular mental abilities—as sensation, feeling, memory, reasoning—in their bearing on intelligence. Some of these are more closely related to each other and to brightness than are others.

The author finds heredity the prime factor in brightness and presents the evidence for this conclusion. In the concluding chapters he points out the necessity of giving different types of training to children of different levels of brightness and describes at some length the methods which have been found useful both at the upper and lower extremes.

FRANK N. FREEMAN, University of Chicago.

THE NATIONAL COMMITTEE ON MATHEMATICAL REQUIREMENTS.

At the last meeting of the General Education Board in New York, on February 28, the sum of $25,000 was appropriated for the use of the National Committee on Mathematical Requirements to continue its work for the year beginning July 1, 1920.

A preliminary report on "The Reorganization of the First Courses in Secondary School Mathematics" was published for the committee by the U. S. Bureau of Education about the middle of February. It has been distributed widely. Copies of the report have gone to all of the State Departments of Education, to all county and district superintendents in the United States and to all City superintendents in cities and towns of over 2,500 population. It has been sent to all the normal schools in the country, to some 1,500 libraries and to almost 300 periodicals and newspapers. In addition it has been sent to about 4,500 individuals, the names and addresses of which were furnished the Bureau of Education by the National Committee. This list of individuals consists chiefly of teachers of mathematics and principals of schools throughout the country. Additions to this mailing list to secure future copies of the reports of the committee can still be made. Individuals interested in securing these reports should send their names and addresses to the Chairman of the committee (J. W. Young, Hanover, N. H.).

A subcommittee, consisting of Professor C. N. Moore, of the University of Cincinnati, Mr. W. F. Downey, of Boston, and Miss Eula Weeks, of St. Louis, has been appointed to prepare a report for the Committee on Elective Courses in Mathematics for Secondary Schools. Any material or suggestions for this report may be sent directly to the Chairman of the subcommittee.

The recent work of the National Committee had a place on the program of the organization meeting of the National Council of Teachers of Mathematics held in Cleveland on February 24 in connection with the meeting of the Department of Superintendence of the National Education Association. Mr. J. A. Foberg of the National Committee on Mathematical Requirements was elected Secretary-Treasurer of the National Council.